PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION

LIBRARY
OCT 14 1920
UNIV. OF MICH.
Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2

VOL. CX.—No. 2857.] *LONDON: FRIDAY, OCTOBER 1, 1920.* [*Registered at the General Post Office as a Newspaper.*] PRICE 1s 2d. BY FOREIGN POST 1s. 5½d.

Rubber MANUFACTURERS
Belting
GUTTA PERCHA & RUBBER, LIMITED
Toronto - - Canada. 8510

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, pages 33 and 96, last week.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd.
Birkenhead.
See Illustrated Advertisement
Page 117, Sept. 10.

Locomotive Shunting Cranes
Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS, SHIPS WINDLASSES, WINCHES, and DECK MACHINERY.
8249
LISTS OF STANDARD SIZES ON APPLICATION.
London Office:
15, VICTORIA STREET, S.W.

Craig & Donald Ltd., Machine
TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1356

CHANTIERS & ATELIERS
Augustin Normand
67, rue de Perrey—LE HAVRE
(France).
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines. 2890

Electric Lifts (UP TO 35 TONS.)
S. H. HEYWOOD & CO., LTD., REDDISH. 8143

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS.
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH. 8329

Brett's Patent Lifter Co. LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1866

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 2907

Telegrams—"Cylinders," Birmingham.
Weldless Steel Tubes
for Water-tube Boilers, Superheaters. Shafting, Hydraulic Work Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. 8179

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR. PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 8708
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17, Sept. 24. 8305

Electric Cranes.
8143
S. H. HEYWOOD & CO., LTD., REDDISH.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 8519

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY AND TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITHS' WORK, IRON AND BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od 3362

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 8303

Excavators.
FROM 50 TO 600 YARDS PER HOUR.
D. Whitaker,
1, UNION STREET, LEICESTER. 7985

"Spencer-Hopwood" Patent
Sole Makers
Boilers.
W. H. SPENCER & CO., HITCHIN, HERTS.
See page 15, Sept. 24. 8421

The Cambridge and Paul Instrument Co., Ltd.,
Manufacturers of Mechanical and Electrical Instruments of Precision.
Head Office and Showrooms:
45, GROSVENOR PLACE, LONDON, S.W. 1.
Works: London and Cambridge. 8194

GOLD MEDAL—INVENTIONS EXHIBITION—AWARDED.
Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 15. 7977

FOR
Railway Wagon Couplings
and GENERAL SMITHY WORK,
write
WELDLESS CHAINS, LTD., Cottbridge. 8184

Iron and Steel
Tubes and Fittings.
8746
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 105.

Royles Limited,
ENGINEERS, ISLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
} How's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8723

Tubes and Fittings,
IRON AND STEEL.
Stewarts and Lloyd's, Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM; and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHERPCOTE STREET.
See Advertisement page 32. 8127

Die Finished Castings ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to SPARKLETS AND GENERAL Mfg. Co., Ltd., Edmonton, London, N.18. 7995

FLEXIBLE, NON-RUSTING
Metallic Hose - Covering to protect & strengthen tubing for all pressures & purposes. As supplied for H.M. Govt. SPARKLETS & GENERAL MFG. CO., LTD., Edmonton, N.9.

Locomotive Traversers
(ELECTRIC).
8143
S. H. HEYWOOD & CO., LTD., REDDISH.

Union Transit Company,
FREIGHT CONTRACTORS.
SHIPPING AGENTS.
INSURANCE BROKERS.
WAREHOUSE KEEPERS and DISTRIBUTING AGENTS
We solicit a trial shipment. 8589
Chief Office: 361, ARGYLE STREET, GLASGOW
Cables and Telegrams: "Transit, Glasgow."

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 8237

Patent
See's Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4836

Diesel Driven Generators,
400-500 Kw., D.C., 500 or 250 Volts, 320 R.P.M., in excellent condition. Low price.
Engines and Dynamos could be sold separately.
Also TWO 500 Kw. Parsons TURBINES, 230-250 Volts, D.C. (in series 460-500 volts), complete with Spare Armature and Condenser.
Exhaust TURBINE SET, Willans-B.C.C., 200 Kw., 440/500 Volts. Complete with Condenser, Pumps, &c.
JENNINGS,
West Walls, Newcastle-on-Tyne. 7990

For Sale.—
MOTOR-DRIVEN
PLANING MACHINE,
To plane 30 ft. by 30 ft. by 10 ft., four Tool Boxes. Condition as new. Makers, Buckton & Co. Price and particulars from—
MURRAY, McVINNIN & CO., LTD., Mavisbank Quay, Glasgow. 8749

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E. 15. 1794

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W. 1.

Yarrow Patent
Water-Tube Boilers.
8706
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1318
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3362

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 90, Sept. 24. 8466

Taylor & Challen
Presses
8196
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM.
See Full Page Advertisement, Sept. 17.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS. **Dumbarton,** 8552
See Full Page Advt., page 82, Sept. 17.

Newcastle Shipbuilding Co.,
LIMITED, HEBBURN-ON-TYNE.
Telegraphic Address: "Watertight, Hebburn."
Telephones: Hebburn 53, 54, 55, 56.
BUILDERS OF PASSENGER, CARGO AND OIL TANK STEAMERS.
Licensees to build under the ISHERWOOD SYSTEM.
Capacity of Shipyard: 8542
10 BUILDING BERTHS UP TO 550 feet.
RIVER FRONTAGE, 1500 feet.

Electric Transporters.
S. H. HEYWOOD & CO., LTD., REDDISH. 8143

AERIAL ROPEWAYS, CABLEWAYS, CRANES
Steel Castings.
8151
See displayed advertisement every fourth week.
JOHN M. HENDERSON & CO., ABERDEEN.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 191, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 8690

Aluminium
8391
THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria St., London, E.C. 4.

See Advt. Page 120, Sept. 24.
Steam Hammers
Power Hammers
Steam and Friction
Drop Stamps.
B. & S. Massey, Ltd., 8393 MANCHESTER.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. B. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. S443

University of Manchester.

EVENING CLASSES in Civil and Mechanical Engineering. These Classes will meet on Mondays, at seven and eight p.m. respectively. FIRST LECTURE OCTOBER 11th. Fee 40s. 6d. each Class. —For further particulars apply to the EXTERNAL REGISTRAR. K 38

Northampton Polytechnic Institute,

200, ST. JOHN STREET, LONDON, E.C. 1.

EVENING TECHNICAL COURSES
In all Branches of
MECHANICAL & ELECTRICAL ENGINEERING
Will COMMENCE on
MONDAY, 27th SEPTEMBER, 1920.

Full-time Sessional DAY COURSES in Engineering and in Technical Optics will Commence on the 4th October, 1920.

The Laboratories, both Mechanical and Electrical, are well equipped with modern apparatus, which, on the Mechanical side, provides for specialisation in Automobile and Aeronautical Engineering, and, on the Electrical side, for specialisation in Alternate and Continuous Current Work, in Radio-Telegraphy and Telephony, and in Electrical Testing.
R. MULLINEUX WALMSLEY, D.Sc.,
Principal. J 919

Battersea Polytechnic,

London, S.W. 11.

ENGINEERING DEPARTMENT.

Full Courses extending over three or four years are given in CIVIL, MECHANICAL or ELECTRICAL ENGINEERING. Recognised for B.Sc. Degree, University of London.
Fees £15 15s. per Session.
ADVANCED EVENING CLASSES.
Suitable for B.Sc. (Eng.); Inst.C.E., and other professional examinations are held in:—
Strength of Materials.
Theory of Structures and Structural Design.
Hydraulics.
Heat Engines.
Theory of Machines and Machine Design.
Classes commence September 27th. For further particulars apply to the SECRETARY. J 870

CITY OF CARDIFF EDUCATION COMMITTEE.

The Technical College.

Principal—CHARLES COLES, B.Sc. (Lond.).

DEPARTMENT OF ENGINEERING.
Head of Department—A. W. Loveridge, B.Sc. (Eng.), A.R.C.Sc.

THE FOLLOWING COURSES
have been arranged for Engineering Students:—
A Three Years' Course in Mechanical and Marine Engineering, jointly with the University College of South Wales and Monmouthshire.
A Two Years' Course for apprentices and others with facilities for practical experience in the Summer Term.
These Courses are suitable for students preparing for degrees in Engineering or for the examinations of the Engineering Societies.
Special Courses are also arranged for Marine Engineers preparing for the Examinations of the Board of Trade.
Further information in regard to Full-time and Part-time Courses, fees, etc., may be obtained on application to the Principal.
JOHN J. JACKSON, B.A.,
Director of Education,
City Hall, Cardiff.
J 888

Inst.C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of Engineering.

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 5–16, Trafford Chambers, 56, South John Street, Liverpool. S433

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—36, Victoria St., Westminster, S.W. S805

Penningtons, University

TUTORS, 264, Oxford Road, Manchester. Estab. 1876. Postal Courses for all Engineering Exams. Enrol now for I.C.E. and I.M.E. Courses. 94 per cent. passes last Exams. 7963

TENDERS.

INDIA OFFICE,
London, S.W. 1,
29th September, 1920.
THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive:—

Tenders from such

Persons as may be willing to supply
PILLAR WATER CRANES.
The conditions of contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that office by two o'clock p.m. on Tuesday, the 12th October, 1920, after which time no Tender will be received.
G. H. COLLIER,
Director General of Stores.
K 51

Belting (Leather, Cotton, Hair

and Balata) WANTED for export to Bombay. TENDERS to JAMES SMITH, Ltd., 21, Bush Lane, London, E.C. 4. J 909

JAMNAGAR DWARKA RAILWAY COMPANY, LIMITED.

Tenders are Invited for the

following materials:—
RAILS, FISHPLATES, FISH-BOLTS and NUTS, DOG SPIKES, and CROSSINGS and SWITCHES.
Forms of Tender, Schedules and Specifications, with General Conditions of Contract, may be obtained from the Consulting Engineers, Messrs. RENDEL, PALMER & TRITTON, 13, Dartmouth Street, Westminster, S.W. 1, on payment of the sum of £1 1s. (which will not be returned). Tenders must be delivered at the above address not later than Noon, on Wednesday, 13th October. J 974

MANCHESTER CORPORATION GAS DEPARTMENT.

LOCO. FOR DISPOSAL.

The Gas Committee are prepared to receive

Tenders for the Purchase and

REMOVAL of:—
One SADDLE TANK LOCOMOTIVE, Four Wheels coupled, Wheel Base 6 ft. 3 in., Standard Gauge.
Cylinders 12 in. diameter by 18 in. Stroke.
Boiler fitted with 130 Brass Tubes and Copper Firebox, Approximate weight unloaded 18 tons.
(Makers, Beyer, Peacock & Co., Ltd., Manchester).
The above can be inspected at the Bradford Road Gas Works, on application to the Manager.
Form of Tender can be obtained on application to Mr. Godfrey Wm. Kaye, Secretary, Gas Department, Town Hall, Manchester.
Sealed Tenders, addressed to the Chairman of the Gas Committee and endorsed "Tender for Purchase of Locomotive," and delivered at the Gas Offices, Town Hall, Manchester.
By Order,
THOMAS HUDSON, Town Clerk.
Town Hall, Manchester,
September 24th, 1920. K 8

FOR SALE.

THE HARROW ELECTRIC LIGHT & POWER CO., Ltd., invite

Tenders for the Purchase and

REMOVAL of:—
Three 60 Kw. Willans-Crompton GENERATING SETS, 460 volts, steam pressure 160 lbs., including one Spare Armature.
One Willan-Crompton STEAM BALANCER, 37 amps., 310 volts, suitable for three wire system 440 and 220 volts.
One 180 Kw. Willans-Siemens GENERATING SET, 460 volts.
Four Babcock WATER TUBE BOILERS, 180 lbs. working pressure; two 30 tubes arranged for hand firing, two 81 tubes fitted with chain grate stokers, 5 HP., 440 volts, Motor and Starter.
One Green's ECONOMISER, 72 tubes, complete with 2 HP. 440 volts Motor and Starter.
One Induced Draft SIROCCO FAN, direct coupled to H.C.C. 9 HP., 440 volts Motor.
One 5 HP., 440 volts, 490 r.p.m. Sturtevant MOTOR.
One Thomas Parker Double Battery BALANCER BOOSTER SET. Boosters 60 amps., 105 volts. Balancer 80 amps., 220 volts, including one Spare Armature.
Sundry Countershafting, Steam Pipes and Valves.
Further particulars and permit to inspect may be obtained from the undersigned or from the Consulting Engineers to the Company, Messrs. May & Hawes, 36, Victoria Street, Westminster.
W. H. BISHOP,
Secretary and Manager.
College Road,
Harrow. J 904

LONDON COUNTY COUNCIL.

To MANUFACTURERS of ELECTRIC TRAMCAR BODIES, TRUCKS and ELECTRICAL EQUIPMENTS, &c.

The London County Council invites

Tenders for the Manufacture,

SUPPLY, DELIVERY and MAINTENANCE of:—
"A" 125 COMPLETE BODIES for ELECTRIC TRAMCARS.
"B" 125 COMPLETE SETS of MAXIMUM TRACTION BOGIE TRUCKS for Electric Tramcars.
"C" 125 COMPLETE SETS of ELECTRICAL EQUIPMENTS for tramcars, together with the assembly of 125 car bodies, sets of trucks, electrical equipments and brakes into complete tramcars, and the preparation thereof in readiness for service operation.
Specifications, Forms of Tender, and other particulars may be obtained on application to the Clerk of the Council at the County Hall, Spring Gardens, S.W. 1, on or after Monday, the 4th day of October, 1920, upon payment to the Cashier of the Council of a fee of £2 each for either "A," "B" or "C" or £5 for the three sets complete. The fee will be returned to the Tenderer, provided he shall have sent in a bona-fide Tender, and shall not have withdrawn the same.
Particulars of the work may be obtained on application at the County Hall previously to the payment of fees for the Specifications, etc.
All drawings and samples referred to in the Specifications can be inspected by appointment with the General Manager, London County Council Tramways Department, 23, Belvedere Road, S.E. 1, on production of either a copy of the specification concerned, or a signed receipt for the fee paid in respect thereof.
Each Tender submitted must be upon the respective official form.
Each Tender with its accompanying documents is to be enclosed in a sealed cover, addressed to the Clerk of the Council, and no Tender received at the County Hall, Spring Gardens, London, S.W., after Four p.m. on Monday, the 25th day of October, 1920, will be considered.
The Council does not, in any case, bind itself to accept the lowest or any Tender.
JAMES BIRD,
Clerk of the London County Council.
J 971

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, Etc., are prepared to receive

Tenders before Eleven

a.m., on Friday, 8th October, 1920, addressed to the SECRETARY, H.M. Office of Works, etc., Storey's Gate, Westminster, S.W. 1, for the SUPPLY of STEAM TUBES and FITTINGS (during a period of six months from date of acceptance of Tender).
Forms of Tender, etc., may be obtained on application to the CONTROLLER OF SUPPLIES, H.M. Office of Works, etc., King Charles Street, Westminster, S.W. 1 K 47

COUNTY BOROUGH OF WALLASEY.

GAS AND WATER DEPARTMENT.

TO ENGINEERS, BOILERMAKERS AND CONTRACTORS.

The CORPORATION OF WALLASEY invite

Tenders for—

(1) The CONSTRUCTION, DELIVERY and FIXING on Seat of One LANCASHIRE STEEL BOILER, 25 ft. by 7 ft., with Mountings and Steam Pipes.
(2) The REMOVAL from their SEATINGS, and RE-ERECTION on other Seatings in another part of the Works, of Two existing similar BOILERS.
(3) The SUPPLY and DELIVERY of about 30 tons of 75 lb. RAILWAY METALS, with Fishplates, Bolts and Dog Spikes, and the Construction, Supply and Delivery of four Sets of Switches, Switch Frames and Crossings.
(4) The SUPPLY and DELIVERY of about 470 CREOSOTED SLEEPERS.
(5) The CONSTRUCTION of Two BRANCH RAILWAY SIDINGS, totalling 300 yards in length.

Plans, Specifications, etc., may be seen, the site inspected, and Forms of Tender obtained on application to the Engineer, Mr. J. H. CROWTHER, at his Offices at the Gas Works of the Corporation, Limekiln Lane, Wallasey.
Contractors may tender for all or any of sections 1 to 5 above, stating the amount of tender for each section quoted for, separately.
Sealed Tenders, on the form provided, addressed to the undersigned and endorsed "Gas Extension," to be delivered per post to my Office, not later than Tuesday, the 16th November, 1920. Tenders arriving at a later time cannot be considered.
The Contractor will be required to enter into a bond with approved sureties, for the due performance of the Contract.
The Corporation do not bind themselves to accept the lowest or any Tender.
Dated this 22nd day of September, 1920.
F. T. COOK,
Town Hall, Town Clerk.
Wallasey. J 984

TO CONTRACTORS.

BELFAST WATER WORKS.

MOURNE SCHEME.

Contract A.

For the Construction of the
"SILENT VALLEY" STORAGE RESERVOIR, &c.

The Belfast City and District Water Commissioners are prepared to receive

Tenders from Competent

CONTRACTORS for the CONSTRUCTION of the "SILENT VALLEY" STORAGE RESERVOIR, &c., in the MOURNE MOUNTAINS, County Down, having an Earthen Embankment about 1,500 ft. long and 90 ft. high, and a storage capacity of 3,000 million gallons, with an Outlet Tunnel, Waste Channel, and other auxiliary works, also the construction of a temporary Works Railway.
The Contract Drawings and Specification have been prepared by the Commissioners' Chief Engineer, Mr. F. W. M'Cullough, M.Inst.C.E., Water Office, Royal Avenue, Belfast, and may be inspected at his Office on any weekday (except Saturday), between the hours of Ten a.m. and Five p.m.
Duplicate Copies of the Specification and Form of Tender, &c., may be obtained from the undersigned upon payment of the sum of Five Guineas. This sum will only be repaid by the Commissioners after the receipt of a *bona fide* Tender which has not been withdrawn.
On the Tuesday and Friday of each week, commencing with Tuesday, the 26th inst., an Assistant Engineer will meet intending Contractors at the Engineer's Office, at Ten o'clock forenoon, and accompany them to the site of the proposed Works.
Tenders, sealed and endorsed "Tender for Silent Valley Storage Reservoir, &c.," must be delivered by registered post, and addressed to the undersigned, not later than Three p.m. on Wednesday, 3rd November, 1920.
The Commissioners do not bind themselves to accept the lowest or any Tender, nor will they be responsible for any expenses incurred in making out a Tender.
W. I. QUINN,
Secretary,
Water Office, Royal Avenue,
9th September, 1920. Belfast. J 787

TO CONTRACTORS.

BELFAST WATER WORKS.

MOURNE SCHEME.

Contract A.

For the Construction of the
"SILENT VALLEY" STORAGE RESERVOIR, &c.

SCHEDULE OF QUANTITIES.

A Detailed "Schedule of

QUANTITIES" has been prepared by me for the above Extensive Storage Reservoir and other Works in the Mourne Mountains, County of Down. Contractors wishing to Tender for this work will be supplied with Printed Copies of the "Schedule of Quantities" on application and payment to me of the sum of Three Guineas per Copy, which sum will not be repayable.
ACHESON FERGUSON,
Quantity Surveyor,
Scottish Provident Buildings,
9th September, 1920. Belfast. J 788

CITY OF MANCHESTER.

THE ELECTRICITY COMMITTEE OF THE MANCHESTER CORPORATION
are prepared to receive

Tenders for the Supply and

ERECTION at their Barton Power Station, Trafford Park, Manchester, of:—
A COMPLETE HEATING INSTALLATION for the Workshop and Stores.
A print of the Drawing and General Conditions of Contract may be had on application to Mr. F. H. Hughes, Secretary, Electricity Department, Town Hall, Manchester.
Further particulars and information can be obtained on application to Mr. S. L. Pearce, Chief Engineer and Manager, Dickinson Street, Manchester.
Tenders, duly endorsed and addressed to the Chairman of the Electricity Committee, must be delivered at the Town Hall, not later than Ten a.m. on Wednesday, the 27th October, 1920.
The firm entrusted with the work will be required to enter into a contract to be prepared by the undersigned.
The Corporation do not bind themselves to accept the lowest or any Tender.
THOMAS HUDSON,
Town Clerk.
Town Hall, Manchester.
28th September, 1920. K 59

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

	Specification Fees.
1. Stationery, &c.	10/-
2. Unbleached White Cotton (Tape & Brown Holland).	5/-
3. Mild Steel Bars, Sections, &c., for miscellaneous purposes.	£1
4. Metals, &c.	10/-
5 Sheffield Tools, &c.	10/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Stationery, &c.," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 12th October, 1920.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Secretary.
Company's Offices,
48, Cepthall Avenue, E.C. 2.
London, 20th September, 1920. K 43

APPOINTMENTS OPEN.

NORTHAMPTON POLYTECHNIC INSTITUTE, CLERKENWELL, E.C. 1.
Civil and Mechanical Engineering Department.
Electrical Engineering and Applied Mechanics Dept.

Wanted, an Instructor and De-

MONSTRATOR in each of the above departments. Salary £315, rising to not less than £440. Teachers will come under the liberal non-contributory Government Superannuation Scheme. Conditions and Forms of Application can be obtained from R. MULLINEUX WALMSLEY, D.Sc., Principal, which should be returned not later than October 11th. K 34

HULL EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL COLLEGE.
Principal: T. Luxton, B.A., B.Sc. (London).

ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

An Assistant Lecturer in

Mechanical Engineering is REQUIRED at the above College, mainly to devote his time to Mathematics and Laboratory Work in Mechanics and Engineering Science.
Salary £330 to £450 with additional payment for Evening Classes. Commencing salary according to teaching experience.
Forms of application may be obtained from the undersigned on receipt of a stamped addressed foolscap envelope and must be returned so as to reach these offices not later than Monday morning the 4th October, 1920.
J. T. RILEY,
Director of Education.
Education Offices,
Albion Street,
Hull, 17th September, 1920. J 890

THE BOMBAY ELECTRIC SUPPLY AND TRAMWAYS CO., LTD., invite

Applications for the Position

of DEPUTY POWER HOUSE SUPERINTENDENT who will be responsible to the Superintendent for the running and maintenance of Power Station Plant of 25,000 kw. capacity. Applicants must have a thorough knowlege of the running and maintenance of H.T. 3 phase Switchgear, Large Turbo Generators, Watertube Boilers and be capable of supervising a large European and Native Staff with tact and firmness. 3 years agreement. Salary Rs. 1000, Rs. 1050, Rs. 1100 per month. Quarters at Power House at nominal rent. Liberal lease and Provident Fund allowance. Passages provided. Applications stating full particulars of experience and training, age, etc., and whether married, to be addressed to the COMPANY, 3, Clement's Inn, W.C. 2. K 32

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.

The Governors require the

Services of Engineering

LECTURERS for day and evening classes:—
Lecturer in Mechanical Engineering.
Lecturer in Mechanical and Electrical Engineering.
Salary Scales:
Grade I. £160—10—£280.
Grade II. £250—10—£300.
The commencing salary in each case will be determined by previous experience in teaching or in industry for which full allowance will be made in accordance with scale.
Particulars may be had from the PRINCIPAL, to whom applications should be forwarded as early as possible. K 66

COLLOIDAL CHEMISTRY AND A "COLLOID MILL."

Some rather remarkable claims on behalf of what is alleged to be a new type of fine grinding disintegrator or "colloid" mill are made by Hermann Plauson in articles recently published in the *Chemiker-Zeitung*. This "Kolloidmühle" is said to be the ideal apparatus for the extremely fine grinding required for homogenising and dissolving substances and for obtaining emulsions and colloidal preparations, and to be particularly valuable in the industries associated with the recovery of oil from oilcake and bleaching earths (Fuller's earth), the manufacture of colloidal or liquid coal, colloidal wood, plastic substances, phosphatic fertilisers, the treatment of lignite, the manufacture of artificial milk, glue, colloidal mercury, soaps and hydrogenated fats.

The writer first refers to the supreme interest and importance of colloidal chemistry and briefly discusses some of the elements of the subject. He says that the most important result recently achieved in this department of science is the recognition of the fact that the three phases: molecular solution, colloidal dispersion, and mechanical (or coarse) suspension, do not represent three distinct and sharply-defined phases, but merge into one another forming a continuous series. All three forms are disperse systems whose physical and chemical characteristics change within definite periods, such for instance as the electrical charging of the ions; and the periodicity of these changes is greater or less according to the size of the spaces in which they occur and the degree of dispersion. Although theoretically there is no hard and fast division between the three phases, in practice certain arbitrary distinctions are made partly by means of the microscope and ultra-violet rays and partly by permeability through filter paper, such as the finest and hardest paper, No. 602, made by Schleicher and Schüll. By these means it is possible to roughly distinguish: (1) Mechanical or coarse suspensions with particles of more than 0·0001 mm. or 0·1 μ in diameter; (2) colloidal dispersions with particles between 0·0001 mm. and 0·000001 mm. (or 0·1 μ and 1 $\mu\mu$); and (3) molecular solutions with particles less than 1 $\mu\mu$. We may say, then, that, practically, mechanical suspensions contain particles which will not pass through ordinary filter paper and are microscopically distinguishable; whilst colloidal and molecular solutions pass through filter paper and their particles are not distinguishable under the microscope. Molecular dispersions or solutions, again, are capable of diffusion and dialysis. From these and other considerations the assertion of the Russian scientist, P. P. von Weimarn, that all matter is capable of assuming the colloidal form may be justifiable.

Methods for the preparation of colloids may be divided into two groups: Firstly, the dispersion method, using solid or coarsely divided substances; and secondly, the condensation method, in which molecules or molecular solutions are dealt with. Chemical or electrical or mechanical energy may be used, and, Plauson adds, also light and heat, as if these latter belonged to a different category from the chemical and other forms of energy. The various methods may be completely classified as follows: I. *Dispersion methods*—(*a*) organic disperse media, (*b*) kathodic disintegration (Bredig), or disintegration by means of oscillatory discharges, and (*c*) heat energy; II. *Condensation methods*—(*a*) chemical reactions, *e.g.*, reduction by metallic salt solutions, (*b*) electrochemical reactions, (*c*) photochemical reactions, (*d*) molecular polymerisation. Hitherto it appears "mechanical power" has not been used. Disperse media (I. (*a*)) are at present only used on a large scale in the varnish, resin and rubber industries, but their use is strictly limited and dependent on certain chemical properties of the materials in question. The ideal and cheapest disperse medium is water, but unfortunately cannot often be used. The other methods of colloidal preparation are not often commercially feasible owing to excessive cost of power and complicated apparatus, or certain difficulties such as the pulverulent form of the material treated, or its low conductivity or low melting-point. It may be concluded then that there is at present no cheap and universally applicable process for the preparation of colloids, *e.g.*, from coal, graphite, cellulose, &c. Plauson says: "This is one of the greatest needs of the chemical and allied industries to-day, but there seemed no prospect of improving existing methods. It is true that solid matter could be finely ground mechanically, but only up to a certain and not very advanced state of fineness, in most cases not less than 0·08 mm. and the utmost fineness possible did not exceed 0·001 mm. (1 μ), requiring excessive power." There was, beside, the risk of explosion, and even with wet grinding designed to remove the explosion risk the degree of fineness was no higher, and the time required was excessive.

The problem of problems is: How can one obtain dispersoids of the highest possible disperse stage from the most varied solid substances? Recognising the supreme importance of a satisfactory solution, Plauson claims that in 1911 he began experiments to determine the optimum conditions for obtaining by mechanical means a disperse stage much higher than hitherto attained. The substances used were coal, talc, graphite, &c. The results, briefly, were: With the usual types of grinding mills the fineness obtained in dry grinding was 0·01 mm. to 0·008 mm., in very exceptional cases and to a very small extent the fineness was 0·001 mm. to 0·0008 mm. With wet grinding the results were a little better, unless an excess of water was used, in which case the results were not so good, except in the case of the so-called beater mill (Schlagmühle or disintegrator) with which further experiments were undertaken using large quantities of water. In 1912 the author designed a modification of the ordinary druggist's "Perplex" beater mill (made by the Alpina-werke) and fitted the shaft with a stuffing-box in order to make the mill watertight. By running such a mill at a very high speed (40 m. per second, presumably this is the velocity at the periphery) Plauson claims to have achieved the fineness of a colloidal solution, exceeding 0·0001 mm. He further discovered that different disperse media gave different results, and that the addition of certain substances to the medium improved the fineness whilst the addition of others did not. For example, in the grinding or "dispersing" of coal greater fineness in less time was obtained when an alkaline solution of glue and certain albuminoids—lysalbic acid and its salts—was added to the medium as accelerator or protective colloid. Tannin used in a similar way with graphite grinding, and neutral soap solution with talc grinding, also greatly improved matters. The same applies to sugar, glutin and allied substances; in grinding colouring earths, ultramarine, &c., and glycerin, glycol, &c., have a very favourable effect in preparing colloidal forms of sulphur, mercury, iodine, &c. Inhibitive substances, such as acids and electrolytes must be removed from the disperse medium by washing or extraction or a larger proportion of protective colloid must be added. The proportion of water or other disperse medium to be used is important, and as a general rule the higher the proportion the better; and the greater the viscocity of the medium the higher the proportion of dispersoid. In grinding coal in water 10 parts of the former would be used with 90 parts of water. But if oil is used as medium the proportion of coal can be increased to 40 per cent. or 45 per cent. But the amount must not be increased too much or a troublesome pasty mass is obtained. The grinding is continued until the surface tension acting on the particles is greater than the force of gravity, or until the particles no longer settle. If a mixture containing a high percentage of "disperse" coal in oil has a further quantity of oil added to it and is then examined under the microscope the Brownian movement of the coal particles can be clearly seen. Mercury can easily be "dispersed" with water if a protective colloid is used, the proportions being 2 or 3 parts of mercury to 97 or 98 parts of water. Most substances, in fact, with sufficient dilution can be made to exhibit all the properties of a colloidal solution. Briefly, then, the general process is as follows: 30 parts of the substance are treated with 70 parts of the disperse medium in a suitable apparatus, diluted with further quantities of medium, and left to stand in a columnar vessel for ½ hour to 12 hours. The supernatant liquid is then drawn off, further quantities of disperse medium are added to the lower part, and the mixture again passed into the beater mill. The drawn-off liquid is perfectly homogeneous and has the characteristics of a colloidal solution. The method and apparatus formerly used were complicated and costly, involving pumps and stirring mechanism, but more recently these latter have been dispensed with and a simpler method evolved. The new machine is called the colloid mill (kolloidmühle), and is manufactured by the Maschinenfabrik Emil Passburg of Berlin. It has already been successfully used on a large scale in a Hamburg works for the manufacture of colloidal cellulose. According to Plauson the mill consists essentially of one or two excentrically arranged discs or pistons carrying beaters of any desired form and revolving at a very high speed. Instead of the beater action of the ordinary disintegrator type friction may be used. A patent was applied for in 1914, and German patent No. 289,026 was granted in 1916 in the name of Georg Hanning of Hamburg, but Plauson claims to have greatly improved the apparatus since then.

In illustration of its manifold uses reference is first made to the petroleum industry, and it is stated that in the American oilfields and also at Baku the crude naphtha is first of all run into large channels or valleys forming the so-called naphtha lakes. When the liquid naphtha is afterwards pumped out there remains a sludge containing from 10 per cent. to 50 per cent. oil which cannot be recovered by distillation owing to fire risk and the high cost of heat required. A sample barrel of the sludge, containing 24·6 per cent. naphtha, was sent to Plauson, who easily recovered the crude naphtha by means of the colloid mill. Ten to twenty parts of the sludge were treated with 90 to 80 parts of water, the whole of the crude naphtha being emulsified whilst the earthy mass quickly settled on standing, so that complete separation was effected in about 5 minutes. By heating the emulsion to 100 deg. C. the oil and water are separated, and in this manner 19·8 per cent. (out of the total 24·6 per cent.) crude naphtha was obtained. By further treatment of the residual mud the naphtha content may be reduced to 1·88 per cent. The separated naphtha still contains from 3 per cent. to 8 per cent. of sludge, but this does not interfere with the subsequent distillation, since crude naphtha distillates are always understood to contain a certain amount. It is claimed that this method will enable many low-grade mineral oils in Germany to be usefully exploited, and be of great value to the chemical industry generally. It should be particularly useful, for example, in extracting the mineral oil from shales which has hitherto been a troublesome and not very paying business.

In reducing the oil content of oilcake, bleaching earths, charcoal, &c., the colloid mill finds another useful application, and instead of the troublesome method of extraction by steam-blowing, or with benzol and the like, it is only necessary to emulsify with hot water in the colloid mill. By adding small quantities of well-known emulsifying agents the residual oil in oilcake may be reduced to 0·8 per cent. to 1·2 per cent. The emulsions formed are very similar to emulsoids (colloidal emulsions), and like these they do not separate very readily, on standing, into two layers. Emulsoids can, however, be rapidly separated when treated in the colloid mill with strong acids: if they are simply mixed and stirred with an equal quantity of acid without being beaten they do not separate. Plauson says he is unable to explain this. Resins, like oils, may be emulsified in the colloid mill, and with water as emulsifying or disperse medium and 1 per cent. to 2 per cent. of a resin solvent, pure resin in a very good yield can be obtained.

Another important use for the colloid mill is in the manufacture of liquid coal. The efficiency of fuel in power plants to-day is admittedly bad, say, about 16 per cent. in triple-expansion engines, 23 per cent. in gas engines and 36 per cent. in Diesel engines. It is probably highest with liquid fuel, and a much more extensive use of liquid fuel is desired; but, so far as Germany is concerned,

there is not more than 400,000 tons of tar oils available annually, and this does not represent more than one-eighth of the total needed. According to the German Tar Products Association, Essen, only about 45,000 tons of tar oils were used for motors before the war, the remainder of the crude oils was used for dyes and chemicals. Attempts have been made to use solid coal for Diesel engines, not very successfully, although it is interesting to note that Dr. Diesel originally wished to use powdered coal, but was compelled to resort to liquid fuel. The use of coaldust for boiler heating has so far been attended with great difficulties—in Germany: it is too bulky and liable to explosion risk. By means of the colloid mill, however, the powdered coal may be emulsified or "dispersed" in oil, and a very satisfactory liquid fuel obtained, for which numerous advantages are claimed, among others—economy in use and in storage, high thermal efficiency, cheap, smokeless, easily regulated, and admirably suited for Diesel engines. It may be prepared in two grades: I. For Diesel engines; II. For heating purposes generally, lower grade coals and even lignites being ground up for the purpose. For Diesel engines the ash content should not exceed 0·8 per cent. to 1·2 per cent. Under present conditions in Germany, and indeed everywhere, this liquid fuel would be particularly useful for shipping, and vast quantities of almost useless coaldust could be advantageously employed. The coal is first ground in ordinary mills to a very fine powder, 30 to 40 parts in 70 to 60 parts of tar oil are then treated in the colloid mill for ½ hour to 3 hours. If a high-speed mill is used and a protective colloid introduced, the time required is less and the mixture becomes perfectly homogeneous and of syrup-like consistency. Beside crude or purified tar oil others may be used, such as mineral oils or distillates, naphtha waste, peat oil, animal and vegetable oils. Water is best avoided at first, although up to 15 per cent. water may be afterwards added. Plauson here refers in a lengthy footnote to the unsympathetic attitude of the German patent office to his applications for a patent, and compares this attitude with that of the English and American offices, even during the war. Apparently he was not successful in obtaining a patent in Germany, through lack of novelty! Probably this is not much to be wondered at, for the subject matter would certainly appear to be rather "thin" in places. At all events his claim to revolutionise the chemical industries by means of a glorified emulsifying apparatus is somewhat extravagant.

The remainder of Plauson's articles deal with the use of the colloid mill in the manufacture of lampblack, colloidal graphite, colloidal wood and straw, treatment of phosphates, in the lacquer and varnish industry, and for facilitating chemical reactions generally, particularly in soap manufacture and the hydrogenation of oils.

The manufacture of soaps, it is claimed, can be simplified by using a steam heated colloid mill. Much less water and heat are required, and in an apparatus of 100 kg. capacity 30 times the amount of soap can be boiled in 8 hours, showing a great saving in labour and running costs, and the resulting soaps were perfectly homogeneous. More water and fillings can thus be incorporated if desired. A still more ambitious claim is made in connection with the hydrogenation of oils ("fat-hardening"). In hardening fats at 120 deg. to 150 deg. with a nickel catalyst the time required was reduced 50 per cent. by using a colloid mill fitted with a steam jacket—or if the same time be used the temperature can be reduced. Plauson says: "By special experiments a new process of hydrogenation was evolved, and the ordinary nickel catalyst was not required if the revolving parts of the mill were coated with nickel or palladium or the like substances. The process is thus greatly simplified." No particulars are given of the manner in which the hydrogen is introduced, or how the catalyst is regenerated or renewed when poisoned or otherwise reduced in activity. However, these and other difficulties could be easily investigated by experiment, and the idea may possibly be worth something. The present methods of hydrogenation are still comparatively new and there is plenty of room for further research.

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*Concluded from page* 403.)

In this our final article on the Olympia Exhibition we propose to deal with a number of automatic machines and with various other tools which we have, owing to lack of space, or for other reasons, been unable to describe earlier. We also propose to make some mention of various of the exhibits which cannot properly be described as machine tools. Although the title of the show was the Machine Tool and Engineering Exhibition, it was essentially concerned with machine tools, and owing to the very important display of this class of product which was made we have been unable to deal to any extent with the more miscellaneous articles which were shown. In the matter of machine tools we think we have been able to give an account of most of the important exhibits, although naturally we make no claim to have illustrated everything that was on show.*

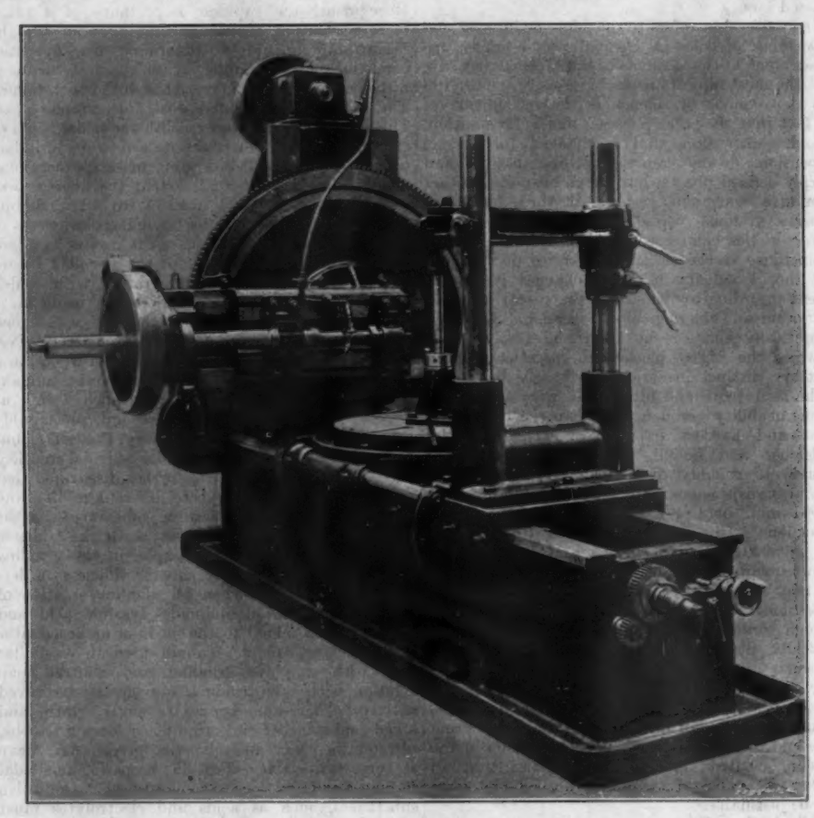


Fig. 195. Gear Hobbing Machine; Messrs. John Holroyd and Co., Ltd.

Gear-Cutting Machines.

We have already dealt, in earlier articles, with many of the important gear-cutting machines which were on show, but there are still one or two we wish to mention. We will deal with these before passing to automatics. The first with which we are concerned in this article was exhibited by Messrs. John Holroyd and Co., Limited, of Perseverence Works, Milnrow, Rochdale, and is illustrated in Fig. 195, annexed. Before describing it we should mention that Messrs. Holroyd had a stall of great interest at Olympia, and showed a considerable variety of machine tools, some of them being of a quite special single-purpose type. Among these there was an interesting copying lathe for manufacturing test-pieces and intended for use in steel works and other places where many test-pieces are required. Another machine of interest was a plain grinder specially arranged and designed for the manufacture of ground shafting and rod directly from the black bar. There were also other novel or uncommon machines, some of which we describe in detail later in this article.

The Holroyd gear cutter, which is illustrated in Fig. 195, will cut the teeth of spur or spiral gears by means of a parallel hob or single cutter, and will also cut worm wheels by means of a sliding taper hob, or a single pointed tool. The machine consists of a bed with a horizontal rotating table carrying the work, and at one end of the bed an upright carrying the cutter head. This cutter head is mounted on a balanced fan slide which has vertical adjustment on the upright by hand or power. The cutter head has self-acting feed and hand-adjustment along its slide and can be set at any angle within its limits. The spindle runs in parallel adjustable gun-metal bearings, and has hardened steel thrust washers. The bracket which carries the front end of the spindle is adjustable along the cross-slide to suit different lengths of hob. The table is adjustable by hand along the bed for setting the depth of cut, and the blank to be cut is centred by a mandrel held in the centre bracket of the table. The table runs on a large diameter flat bearing on the slide, and is held central by a taper spindle running in adjustable bearings. It is revolved by a worm gearing. The drive is by belt from a reversible countershaft to a cone pulley on the machine, which drives a cross-shaft through a two-speed gear-box. This cross-shaft is geared to a vertical shaft in the upright which drives the internal gear wheel at the end of the spindle through mitre gears. The table is driven from the gear-box at the back of the machine.

* Note.—In connection with the article on the Machine Tool and Engineering Exhibition in our issue of last week, by an unfortunate transposition the titles on Plate L are shown wrongly placed. The lower title, "Figs. 160 and 167, 72-in. Cylindrical Grinding Machine" should have been under the two upper illustrations, while the title "Figs. 168 and 169, 36-in. Universal Grinding Machine" pertains to the two lower views. We very much regret the mistake, but venture to hope that our descriptions are sufficiently clear to make it evident which illustrations are actually referred to in spite of the incorrect indications of these titles.—Ed. E.

Two gear-cutting machines of similar class were also shown by Messrs. Humpage, Thompson & Hardy, of Jacob-street, Bristol. These machines were respectively of 16 in. and 42 in. types. The machines are purposely designed as simple as possible, and can cut both spurs and worms. For the latter a hand-feed is used, but for spur-gearing the machines are entirely automatic. The machines have no countershaft, and the main drive is by belt to a pulley on the top of the column. Change-wheels provide four speed changes. The hobbing cutter is fed downwards, and is carried by a slide moved by means of a vertical screw. Another slide carries the revolving work-table which is moved into the required position by means of a horizontal screw. The swivelling head which carries the hob is controlled by a hand-screw, and a vernier reading to five minutes is provided. The automatic feed is positive, and can be varied over a wide range by means of change-wheels. The work is steadied by means of two bars, connecting the top of the mandrel to the column of the machine. This enables heavy cuts to be taken without acrifice of accuracy.

TWIST-DRILL GROOVING MACHINE.

We have already referred to some of the interesting exhibits which were made by Messrs. John Holroyd & Co., Limited, of Milnrow. Another of these was an example of the Bergstrom twist-drill grooving and backing-off machine. This machine is illustrated in Figs. 196 and 197 on Plate LIV. Its general features will be gathered from the illustrations. The drill blank is held in a collet, which is at one end of a screwed rod, a handle being fixed at the other end. The operation of screwing the rod into a specially-cut cylinder closes the collet and grips the blank. Further motion causes the blank to enter the split guide bush in which it is cut, and as this bush is under tension there is no possibility of play between the bush and the drill blank. The machine, as will be seen, has four cutters. It will drill two grooves and back-off the drill on both sides simultaneously. The cutter spindles are of tool-steel, and have ball bearings at the back of the driving pulleys. The pulleys are massive, and impart a smooth action to the cutters. The machine can be supplied for constant or increasing twist, or for parallel or increasing core thickness. A geared oil pump is incorporated and a channel round the machine returns the oil to the supply tank.

AUTOMATIC MACHINES.

We propose now to deal with a number of the automatic machines which were on view, and may begin by referring to Fig. 198 on Plate LIV. This illustrates the Verity's patent automatic screw machine made by Messrs. Thomas White & Sons, Limited, of Laighpark, Paisley. This tool has many points of novelty. It is of simple construction and intended for large-scale production. The complete cycle of turret operations may be made in four seconds, and with the range of spindle speeds arranged for, a production varying from 30 to 100 per hour, may be obtained. With extra gears a production up to 720 per hour is claimed to be possible. The drive to the machine is by a single belt running on a two-speed cone pulley at the back of the machine, and power is transmitted from the pulley spindle to the main spindle through steel gears. These gears give four speeds to the spindle, which runs in phosphor-bronze bearings, which are carried in tapered housings adjustable to take up wear. All the tools cams are carried on a cylinder which is mounted concentric with the main spindle, and runs on a sleeve. The position of the cams in the head of the machine makes them very accessible for setting-up, as will be clear from the figure. A handle is provided by which the feed motion may be thrown out of gear, and the cam cylinder can then be revolved by a loose handle supplied with the machine.

The arrangements in connection with the turret form one of the special features of the machine, the turret being pulled to the work by a rod attached to a slide carrying a roller, which engages with the cam. This rod passes through an extension on the turret-slide to which it is attached by a clamp bolt. The turret may be clamped to this rod at any position within its travel, so that if a 2-in. to-and-fro motion is arranged for, this 2 in. may be close up to the headstock or four or five inches away. The revolving and locking of the turret is carried out by a gear underneath the slide which can be made to operate in any position of the turret. The form tool and cut-off tool are carried in slides in the face of the headstock, and so do not block the bed in any way. Three such tools are arranged for. A further special feature of the machine lies in the special threading attachment which may be fitted. An ordinary self-opening die may be used if desired, but with the special attachment the work is not slowed down for screwing, but the die is rotated in the same direction as the work, but at 50 per cent. higher speed. This gives the equivalent of a 50 per cent. screwing speed, but output is helped since the speed of the work has not to be changed. The arrangement is operated through a special shaft connecting from the top of the turret to the driving gear.

A simple three-operation automatic machine, which was exhibited by Messrs. the Timbrell & Wright Machine Tool and Engineering Company, Limited, of Slaney-street, Birmingham, is illustrated in Fig. 199 on Plate LIV. It is suitable for producing any articles requiring three machine operations, such as turning, forming and cutting-off, or drilling, forming and cutting-off. The automatic movements are obtained from cams bolted to drums carried by a cam-shaft at the back of the machine. This shaft is driven by a worm and worm-wheel and has fast and loose pulleys on the worm-shaft, so that the camshaft can be started and stopped while the machine spindle is in motion. This spindle runs in adjustable phosphor-bronze parallel bearings, and has a ball-thrust. The cutting-off rest is fitted with two square tool posts, which have longitudinal adjustment in slots. The slide which carries the front tool post has transverse adjustment. The tail stock is arranged to carry either a drill or a facing or turning, tool. It has longitudinal movement along the bed, and is fitted with an adjustable stop for gauging the length of the work. The maximum capacity through the automatic feed is $\frac{7}{8}$ in.

Certain continental countries have for long had a good reputation for small automatics, and some of these are represented at the show. The Swiss firms, who have always done well especially in the construction of small tools for the production of details, had some interesting tools on exhibition, and we now illustrate on Plate LV one of a series of machines made by the well-known firm of Messrs. Joseph Petermann, Moutier, Switzerland.

This machine is quite unlike the ordinary automatic based on the accepted turret lathe design. A front view of the tool is shown in Fig. 200 from which it will be seen that the headstock is on the right hand, and the tool rests to the left of the machine. Another difference is that the headstock travels to and fro, while the tools only have cross traverse, instead of the headstock being fixed and the tools having longitudinal traverse. Other features will appear as we proceed. Fig. 201 gives a back view of this machine, showing the driving cone pulley and the camshaft, the latter being shown by itself in Fig. 202. The disposition of the forming and parting tools is shown in Fig. 203, while Fig. 204 shows an attachment for drilling and tapping, fitted to the left-hand end of the bed, and Fig. 205, one of two methods of controlling the movement of the headstock. The movement of the headstock is controlled by two methods according to the class of work to be done. The parts needed for either can be attached to the machine, so that work requiring two quite different forms of movement can be accomplished on the one tool. One method consists of controlling the headstock by a slide having a slanting slot. The slide is moved across the bed by a cam-plate on the camshaft, and a pin in the slot causes the headstock to move on the bed. In the second arrangement shown in Figs. 201 and 205 the cam takes the form of a bell which actuates a lever coupled to the headstock which advances and recedes in accordance with the cam profile.

One camshaft controls all the movements of the machine. It is driven as shown in Figs. 201 and 202 through worm and worm wheel. The correct length of stock bar is gripped by a collet in the headstock spindle, and this is carried forward through a bushed steady shown in Fig. 203. In the case of short and stiff jobs the bush is not used, the chuck on the spindle itself passing into the hole of this steady and moving right up to the line of the tools. The two upper tools shown in Fig. 203 are brought into action by cams on the camshaft, operating rocking levers above the vertical slides. The two lower tools are mounted on a rocking lever pivotted below the work centre and also operated by cam, the two tools being brought into action alternately. The tool holders are designed to be quickly removed and replaced when grinding is necessary; they are provided with adjustments in all directions.

The one camshaft controls the movement of the tools, the headstock feed, the drilling and other attachments, the chucking of the work, &c., ensuring perfect synchronism of the operations. The shaft can be worked by hand wheel through an intermediate shaft for making adjustments. The cams are all carefully checked by micrometer in order to ensure accuracy in the work. The stock feed is accomplished in two manners according to the work. If the character of the work permits, one of the tools is advanced as a stop, and the bar fed out against it by the pull of a weight after opening the collet. The collet is then closed and the cutting cycle commenced. This system is only used if the stock will not damage the tool or *vice versa*. If there is risk of harm arising the second method is used. In this a cutter is advanced up to the bar which is then held in the steady. The headstock is then traversed back the proper amount, and the collet is closed and the cycle recommences. The feed mechanism stops the machine when the stock is exhausted.

The accessories capable of being attached at the left-hand end of the machine include that shown in Fig. 204 for drilling and tapping, single or double spindle drilling, screw cutting (both right and left handed), recessing, &c. A taper turning attachment is also arranged to fix on the rocking tool lever. Every care has been taken to produce a tool capable of exact work, and every effort has been made to cut out idle time.

In addition to the one we have already described, Messrs. Thomas White & Sons, of Paisley, also showed the automatic which is illustrated in Figs. 206 to 208 on Plate LVI. This machine is capable of producing all classes of bar work, such as screws, nuts, thimbles, collars, &c., and is quickly adaptable for different jobs without changing pulleys or using special cams. The machine is self-contained, and requires no countershaft. A constant speed pulley on the machine drives through an all-gear speed box and also provides a variable feed to the turret, form and cut-off tools. Power is transmitted from the constant-speed pulley through a friction clutch controlled by the lever, which can be seen alongside it in Fig. 206, so that all motions may be instantly started or stopped. A hand-wheel at the other end of the machine is provided for use when setting-up. It is of self-releasing type, and does not revolve when the machine is running under power. The gear head gives 16 spindle speeds, ranging from 122 r.p.m. to 1,251 r.p.m. in geometrical progression. Reverse is available on all speeds. The spindle is hardened and ground, and runs in phosphor-bronze bearings, and in the machine we illustrate admits bars up to $\frac{7}{8}$ in. diameter. A larger size of machine takes $1\frac{1}{4}$ in. bars. The collet chuck and feed finger are operated from the cam drum, and a scale on the drum is provided to facilitate adjustment for length.

The cross-slides for holding the form and cut-off tools have independent feed, and can act separately or simultaneously with variable feed under automatic control. Fine adjustment of the tools is obtained by screw and lock-nut. The slides are operated by cams fixed to the slide cam disc. They are fitted with push-out springs and return quickly from the work when the cut is finished. No return cams are used. The feed control of the machine is by means of the left-hand lever of the three shown in Fig. 208. This lever controls the motion

of the feed shafts which are carried along the rear of the machine, and can be seen in Fig. 207. The upper of these two spindles has a constant speed, which is irrespective of the spindle speed. It controls the rotating of the turret, the opening of the collet, the feeding of the stock, and the bringing forward of the tools to their cutting position at maximum speed. The bottom, variable-speed shaft, operates the cam-drum shaft by means of dogs. Three rates of feed can be automatically obtained for each spindle speed, so that, in conjunction with the constant-speed shaft, one set of cams can be used for a large variety of work, and all non-cutting motions are done in minimum time. The turret cam-drum has tapped holes spaced all round, so that the cam-plates can be quickly adjusted for special work. In conclusion, and in reference to Fig. 208, it may be said that the central lever controls the fast and slow motions of the main spindle. In conjunction with each of these motions, eight speeds are available through the gear-box, giving in all the 16 speeds already referred to. The right-hand lever in Fig. 208 controls the reverse of the main spindle.

Automatic machines were also shown by Messrs. A. Butterworth & Co., of Ainsworth-street, Rochdale. The Butterworth machine is of the chucking type, and is fully automatic, except for the placing of the work in the chuck and withdrawing it. One operator can attend to from two to six machines, depending on the class of job being handled. The machines have single pulley drive, and three automatic changes of spindle speed. There are five feed changes to the turret, operated through a gear-box, and two feeds to the cross-slide. Automatic stop motion is fitted. A full automatic turret lathe was shown by Messrs. Greenwood & Batley, Limited, of Albion Works, Leeds. This is intended for the manufacture of screws, studs, &c., and a screw-slotting attachment is incorporated. A turret with five tool holes is provided and a cross-slide with holders for tools back and front. The auto-chuck will take bars up to $\frac{3}{4}$ in. diameter, and the automatic feed will advance bars up to $4\frac{1}{2}$ in. in one movement. Small automatic screw machines were also shown by Messrs. The Centaur Tool Works, Limited, of Smethwick, Birmingham and Messrs. The George H. Alexander Machinery, Ltd., of Birmingham.

Lathes.

There are still a number of lathes with which we wish to deal, and from among these we may first refer to the $\frac{1}{8}$-in. capstan which was exhibited by Messrs. The Timbrell & Wright Machine Tool and Engineering Company, Limited, of Birmingham; this is illustrated in Fig. 209 on Plate LVI. Messrs. Timbrell & Wright had a very attractive display of the smaller type of capstan lathes, and our figure shows a characteristic example. The machine will take bars up to $\frac{1}{8}$ in. diameter, and has six automatic revolving stops to the capstan slides, and a two-speed countershaft. The headstock is cast solid with the bed, and the spindle runs in adjustable phosphor-bronze parallel bearings. The cone pulley is turned inside and out, and is secured to a taper part of the spindle without a key. The automatic feed chuck is operated by a hand lever, and acts without stopping the lathe. When releasing the bar the tube is returned by the toggles, and does not depend on the spring of the collet. By removing the automatic feed and using an ordinary chuck a larger bar can be admitted through the spindle. The turret has six holes for tools, and the index ring and plunger bolt are hardened and ground. A split steel sleeve hardened and ground, and adjustable for wear, surrounds the plunger bolt. The cut-off slide has two adjustable tool-holders.

A lathe of more than ordinary interest was shown by the Colchester Lathe Company, and is illustrated in Figs. 210 and 211, Plate LVI. This lathe has been produced especially to meet American competition and should go a long way in this direction, as its price is very attractive as figures go now-a-days. It is a high-speed, all-geared 8½-in. lathe, with quick-change feed gears and vee bed. All conflicting motions are interlocked. A very good idea of the speed gear-box of the head-stock is obtainable from Fig. 211. The constant speed pulley is driven from a fast and loose pulley countershaft. The speeds range from 18 r.p.m. to 305 r.p.m. there being eight changes, obtainable by means of two levers. Speeds can be changed in less than five seconds. The spindle is hollow, bored to take a 2-in. rough bar. It runs in parallel phosphor bronze bearings, the front one being $3\frac{7}{8}$ in. diameter by $4\frac{1}{2}$ in. long. The end thrust is taken on a ball-thrust washer.

The feed gear-box is of the Hendy-Norton class, and gives 32 feeds, ranging from 8 cuts per inch to 120 cuts per inch. For screw-cutting the range is 32 different pitches from 4 per inch to 60 per inch, also taken care of by the same gear-box. The saddle has bearing surfaces 24 in. long. At the back it runs on a vee; in front on a vee and the flat front guide of the bed. The apron is double-walled. The lead screw is used for thread cutting only, feeds being taken from the feed-shaft by means of dropping worms. A thread indicator facilitates the correct engagement of the lead screw. The sliding and surfacing motions are interlocked. The slide-rest is indexed and can be swivelled through any angle. The tail-stock is also adjustable for taper-turning. The bed will admit of work 3 ft. 4 in. between centres. As we have already stated, the lathe is 8½ in. centres, or, as the makers class it, 17 in. swing-over bed, and 12 in. over saddle. The effort made in this instance to produce a high-powered modern lathe at a reasonable cost is certainly deserving of success.

The latest Willson 8½-in. tool-room lathe is illustrated in Fig. 212, annexed. A gang of several of these machines was shown by the makers, Messrs. Smith, Barker & Willson, Limited, of Halifax. This lathe has several uncommon features. As regards the machine itself, the bed is a bellied box girder. The guide and front support for the saddle is a special hardened steel vee, fixed to the side of the bed. This enables a good wearing surface to be provided, while the vee is in a protected position, and one giving a direct support to the saddle. The saddle bearing on the guide is 25 in. The bed top does not touch the saddle. The screw and rack are placed well up under the ways, and are both well protected by virtue of their position. The cross-slide is 20 in. long, or nearly as long as the saddle is wide, thus protecting the slide.

The drive of these lathes is unique. Overhead shafting of all kinds is dispensed with, and a boxed-in shaft on the floor drives the machines through worms and clutches operating the main gear-box in the cabinet leg under the head-stock. The changes, which are made by sliding gears on a castellated shaft, are four in number. The drive from this gear-box to the head-stock is by an enclosed belt. There are two sets of back gear in the head-stock so that 12 spindle speeds are obtainable. The gear-box changes are effected by turning a handle on the leg below the head-stock, and an automatic revolving indicator shows at a window what speeds the back gears or direct drive will give. The back gears are engaged by friction clutches, operated by a lever in front of the head-stock. Another lever just above the last is for the friction clutch of the spindle. The end-thrust of the latter is taken by a ball-thrust bearing. The feed changes, arranged in the feed change-box, are 12 in number, but four change-wheels allow two other main changes which altogether make the range of feeds 36, or from 2 to 96 threads per inch for screw-cutting. Feeds and traverses are interlocked. A reverse is arranged for the lead screw, operated by or from the saddle. This automatic control is effected by dogs on a rod below the apron.

Figs. 213 to 216, page 433, illustrate a very workmanlike surfacing and boring lathe. This has 13-in. centres. It is fitted either with a hexagon turret or square tool post for four tools. It is made by the Colchester Lathe Company. This machine has six speeds, with two speed countershaft, making twelve speeds in all ranging from 12 to 324 r.p.m. The two-speed countershaft runs at 100 and 240 r.p.m. and has 14-in. fast and loose pulleys. The largest pulley of the cone is $12\frac{1}{2}$ in. and the smallest $9\frac{1}{2}$ in. The spindle front bearing is $3\frac{7}{8}$ in. by $4\frac{1}{2}$ in. The thrust is taken on a ball thrust washer, and the spindle is bored for 2-in. rough bar. The feed box gives 32 feeds, ranging from 8 to 120 cuts per inch., or for screw cutting from 4 to 60 threads per inch in 32 steps.

The bed is very heavy and strong for the size of lathe. It is 6 ft. 7 in. long. The bearing surfaces for the saddle are very wide, and it will be seen that additional support is given to the saddle by a slide below the apron in front. This is carried on brackets on the bed, and when the turret or tool post is traversed well forward to work on jobs of large diameter, this slide gives a direct support under the cutting point. The arrangement will be clear on reference to our illustrations, and particularly the general view, Fig. 213, and the sectional drawing Fig. 215. The support is carried to the saddle through the apron which is of the double walled type. The self-acting sliding and surfacing motions are engaged by drop worms, and phosphor bronze wheels. An adjustable stop is provided on the bottom slide, engaging with a knock-off on the apron for cutting out the longitudinal feed. The longitudinal traverse, cross traverse and screw cutting motions are interlocked, and only one can be engaged at one time. The reversing gear can be thrown in without stopping the lathe. The machine is fitted with a very substantial turret carrying six tools or fixtures. The lathe has every appearance of a machine of good capabilities well up to its work. The same machine, as stated above, can be fitted with a square tool post to

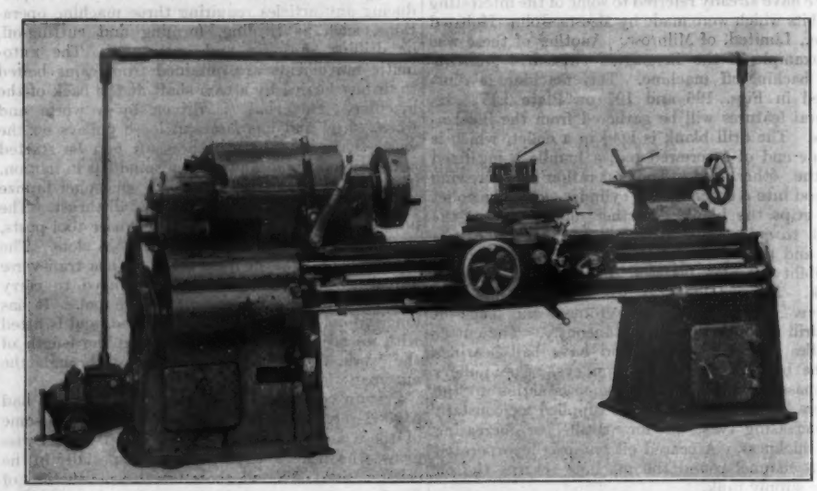


Fig. 212. 8½-In. Tool Room Lathe; Messrs. Smith, Barker and Willson, Ltd.

take four tools, a locating pin being provided for each setting.

While dealing with lathes, though we are not able to describe at length other exhibits, mention may be made of the machines shown by Messrs. Brown and Ward, Limited, who had on view a 6-in. lathe for tool room work, and a 9-in. spinning lathe. Messrs. Denham's Engineering Company, Limited, Halifax had four good class lathes, one with an all gear headstock, and a 6½-in. tool room lathe. Messrs. Holbrook and Sons, Stratford, London, had both a 6-in. and a 7-in. tool room lathe on view. The former is provided with cone pulley and change gears, with stops to the movements, micrometer dials, etc. The larger machine has a feed change gear box giving 36 changes without loose gears. It also has automatic stops. Messrs. John Birch and Company, Limited, 2, London Wall Buildings, E.C., had lathes of the smaller sizes on view. The 3½-in. Birmell screw-cutting lathe they were showing has a bed with a short central base, the floor model being mounted on a central column, making a very neat machine. This machine is arranged for screw cutting, and power friction drives are provided for the sliding and surfacing movements. The tool rest swivels and is of the square pattern, accommodating four tools. The firm also had at their stands 4-in., 4½-in. and 5½-in. lathes of rather different pattern.

Swivel Head Slotting Machine.

Slotting machines did not form a very prominent feature of the Exhibition, but in a previous article we illustrated one of more than common interest. Another interesting machine is shown in our illustrations, Figs. 217 to 219, Plate LVII, of a slotter with a swivel head, made by Messrs. Harry F. Atkins, Limited, Old Fletton, Peterborough. This machine is made in two sizes, of which we illustrate the 6½-in., the other being an 8½-in. machine. The drawings and photograph show the chief characteristic of the tool pretty clearly. The head swivels ten degrees either side, and the tool-box is also made to swivel in the head so that the tool will face in any direction. The tool also is relieved on the up stroke. There are three speeds on the smaller tool, and four for the larger. The traverses to the table are either hand or automatic, including the movement to the circular table. The longitudinal and cross movements are 12 in. for the 6½-in. machine. The diameter of work admitted is 36 in., the column being set well back. The circular table can be set and locked in any position giving 3, 4, 6 and 12 regular-sided figures, and it is graduated in degrees. The working surface of the circular table is 16 in. The feeds are by ratchet, and range from 0·004 in. to 0·024 in. A brake, operated by treadle, is arranged on the flywheel, so that the ram may be stopped at the top of the stroke.

High-speed Internal Grinding Spindle.

In connection with their display of grinding machinery, Messrs. A. A. Jones & Shipman, Limited, Leicester, showed a small internal grinding spindle, running at the exceptionally high speed of 104,000 r.p.m. This is a small spindle for very fine internal precision work, the diameter of the wheel being ¼ in. With this small diameter, in order to obtain the correct surface speed, this high rate of revolutions has to be adopted. The speed is said to be twice as high as is attempted with other spindles. Fig. 220, Plate LVII, shows the double reduction used from the motor drive. The motor runs at 2,500 r.p.m., and the intermediate spindle at 9,167 r.p.m. From Fig. 221, which shows a longitudinal section of the spindle, it will be seen how it is mounted in its ball bearings. The spindle is ½-in. in diameter where the cones are fitted. Each bearing has twelve ⅛-in. balls.

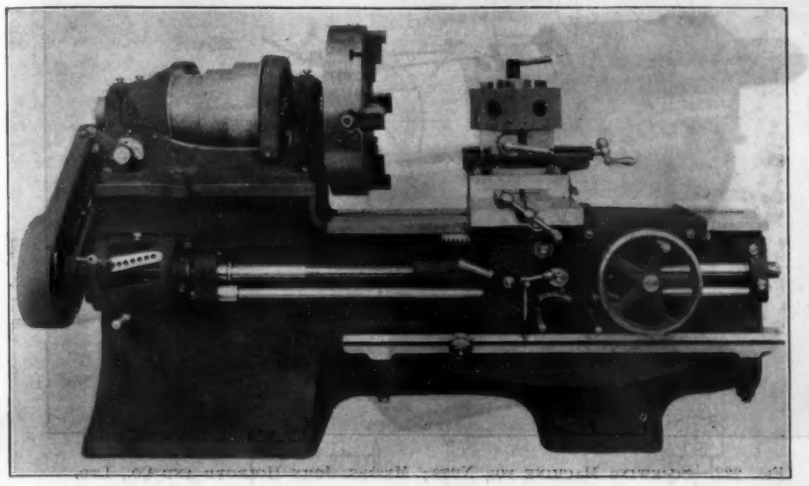


Fig. 213.

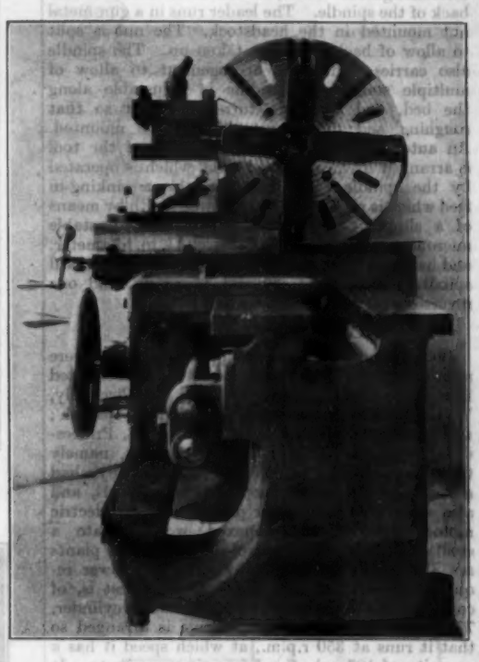
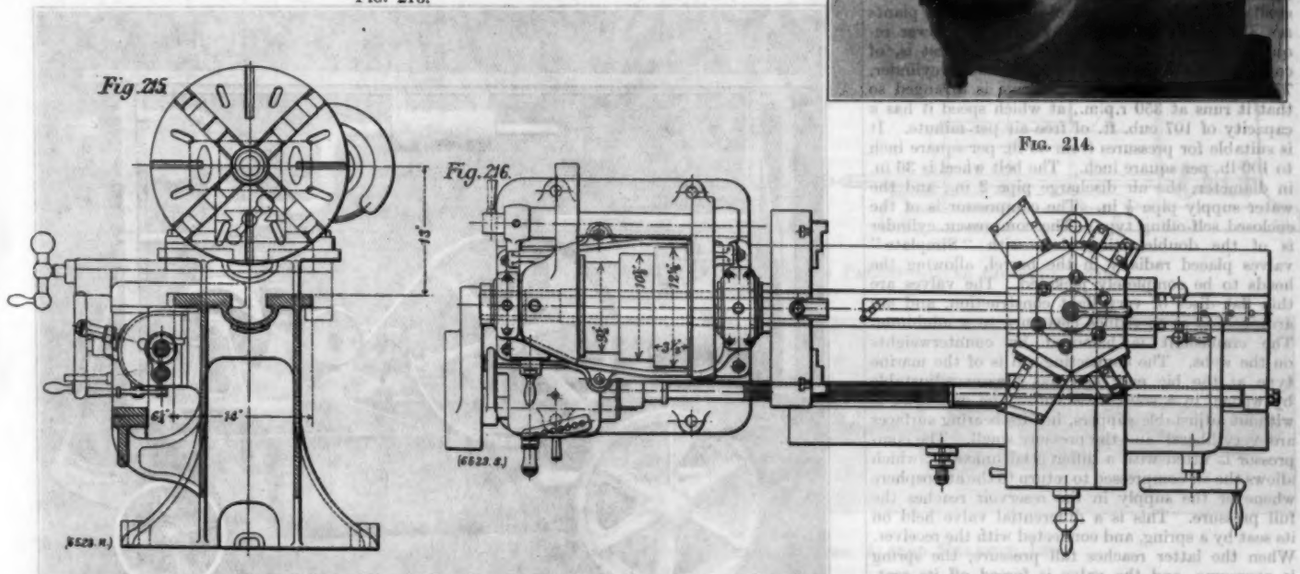


Fig. 214.



Figs. 213 to 216. 13-In. Surfacing and Boring Lathe; The Colchester Lathe Company.

Screwing-machine For Nuts.

An interesting and useful machine which it is difficult to place in any definite class, was exhibited by Messrs. John Holroyd & Co., Limited, of Milnrow. It is illustrated in Fig. 222 on page 434. The machine is intended for screwing right-

or left-handed nuts of different shapes. It consists of a bed carrying a headstock and tool-slides. The work spindle is of cast-iron of large diameter, and is carried by the headstock. The drive is by belt on fast-and-loose pulleys, and through a variable speed gear-box to a worm and worm-wheel. A chuck or jig-plate to hold the work is mounted on the front end of the spindle. The travel necessary to cut a thread is obtained by longitudinal movement of the main spindle, the tool remaining stationary. The lead is given to the spindle by an interchangeable leader, which is fastened to the back of the spindle. The leader runs in a gun-metal nut mounted in the headstock. The nut is split to allow of backlash being taken up. The spindle also carries a dividing arrangement to allow of multiple starts. The saddle is adjustable along the bed, and carries a turret-tool post so that roughing and finishing tools may be mounted. An automatic release and positioning of the tool is arranged by means of a toggle, which is operated by the spindle. The tool has also a sinking-in feed which is released at the required depth by means of a slipping clutch operated by an adjustable micrometer stop. The spindle is 4½ in. diameter, and has a traverse of 9 in. There are three forward spindle speeds of 15, 30 and 45 r.p.m., and one reverse of 50 r.p.m.

Compressed Air Plant.

Compressed air plant and pneumatic tools were represented mainly by exhibits by the Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, W. 1.; by Messrs. Reavell & Co., Limited, Ipswich; and by Messrs. Mossay & Co., Limited, 7, Princes-street, S.W. 1. The first of these firms, namely the Consolidated Pneumatic Tool Company, had a large assortment of pneumatic hand tools, and also a portable compressor plant driven by electric motor. In Fig. 223, annexed, we illustrate a similar plant driven by petrol motor. These plants are also made for driving by oil. The power required is about 18 h.p. The chief interest is, of course, in the compressor which has a single cylinder, 7½ in. by 6 in. stroke. The drive is arranged so that it runs at 350 r.p.m., at which speed it has a capacity of 107 cub. ft. of free air per minute. It is suitable for pressures from 50 lb. per square inch to 100 lb. per square inch. The belt wheel is 36 in. in diameter, the air discharge pipe 2 in., and the water supply pipe ½ in. The compressor is of the enclosed self-oiling type. The compressor cylinder is of the double-acting class with "Simplate" valves placed radially in the barrel, allowing the heads to be completely jacketed. The valves are thin flat discs of very light construction, and are arranged so as to reduce clearance to a minimum. The crankshaft is balanced by counterweights on the webs. The connecting-rod is of the marine type at the big end, and has brasses adjustable by wedge, in a solid little end. The crosshead is without adjustable slippers, but its bearing surfaces are very liberal and the pressure small. The compressor is fitted with a differential unloader, which allows the air compressed to return to the atmosphere whenever the supply in the reservoir reaches the full pressure. This is a differential valve held on its seat by a spring, and connected with the receiver. When the latter reaches full pressure, the spring is overcome, and the valve is forced off its seat, when its effective area is increased, and it is held on a bottom seating, allowing air to escape through a sleeve and pipe. When the pressure has fallen a certain amount the valve closes. The belt drive is arranged with a heavy jockey pulley to keep the belt taut, and increase the arcs of contact. The air reservoir is placed beneath the frame.

Messrs. Mossay and Co., Limited, 7, Princes-street, Westminster, S.W. 1, who are the agents for various types of pneumatic tools, had an assortment of pneumatic hand tools for various purposes, including mining tools, picks for road work and engineering, light and heavy riveting hammers, boiler scaling hammers and rock drills. The Eloy pick shown by this firm has been used with very good results in cutting concrete when it has been necessary to cut through old work in connection with, for instance, new foundations. Messrs. Reavell and Co., Limited, Ipswich, exhibited several compressors, some of which were shown with portions removed so that the functions of the various parts could be followed while they were running. The sets shown included a quadruplex compressor of 672 cub. ft. capacity, working at 120 b. A portable set of 75 cub. ft. capacity was also shown, belt-driven by a Parsons petrol engine.

Forging Appliances.

Two firms had exhibits connected with the heavier side of forging. Although, of course, it was not to be expected that really heavy stamps could be shown, both demonstrations attracted a good deal of interest. One we hope to refer to at a later date, and at present confine ourselves to the exhibit of Messrs. Bretts Patent Lifters Company, Limited, Coventry. This company exhibited a 7-cwt. self-contained friction drop stamp, and their latest type of 400 lb. automatic drop hammer which will give 60 blows per minute. It is controlled by a treadle. A 200 lbs. mechanical hammer was also shown by this firm, and is illustrated in Figs. 224, 225 and 226, page 435. This is a belt-driven hammer with a free tup giving an elastic blow. It is a most useful design of small hammer. The belt normally is rather slack, and when the hammer is worked, is tightened by means of a jockey operated by the treadle in front of the anvil. The pulley flywheel is keyed to a shaft at the other end of which is an adjustable crank on which works a short connecting rod. At the lower end of the latter is a crosshead in which are housed the upper ends of two spring arms. These pass within the tup where they are fitted with rollers running on curved roller paths. The tup is thus not fixed rigidly to the arms, and on the latter moving up and down, following the rotation of the crank, the tup is allowed a certain elasticity of movement. The tup slides have a long tapered adjusting shoe on one side. The flywheel pulley is fitted with a brake applied when the treadle is released.

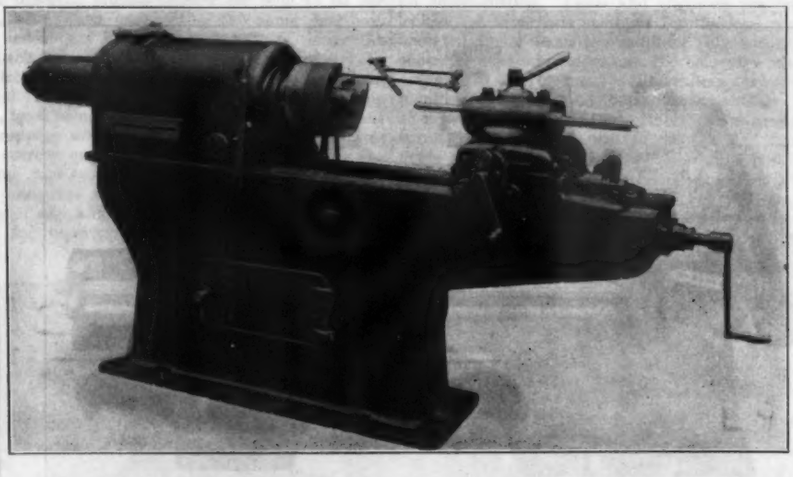


Fig. 222. Screwing Machine for Nuts; Messrs. John Holroyd and Co., Ltd.

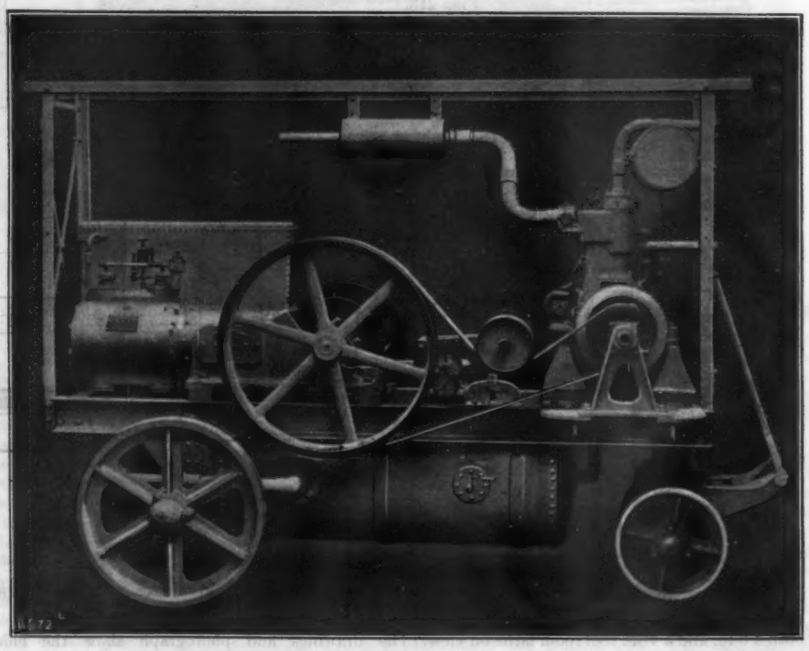
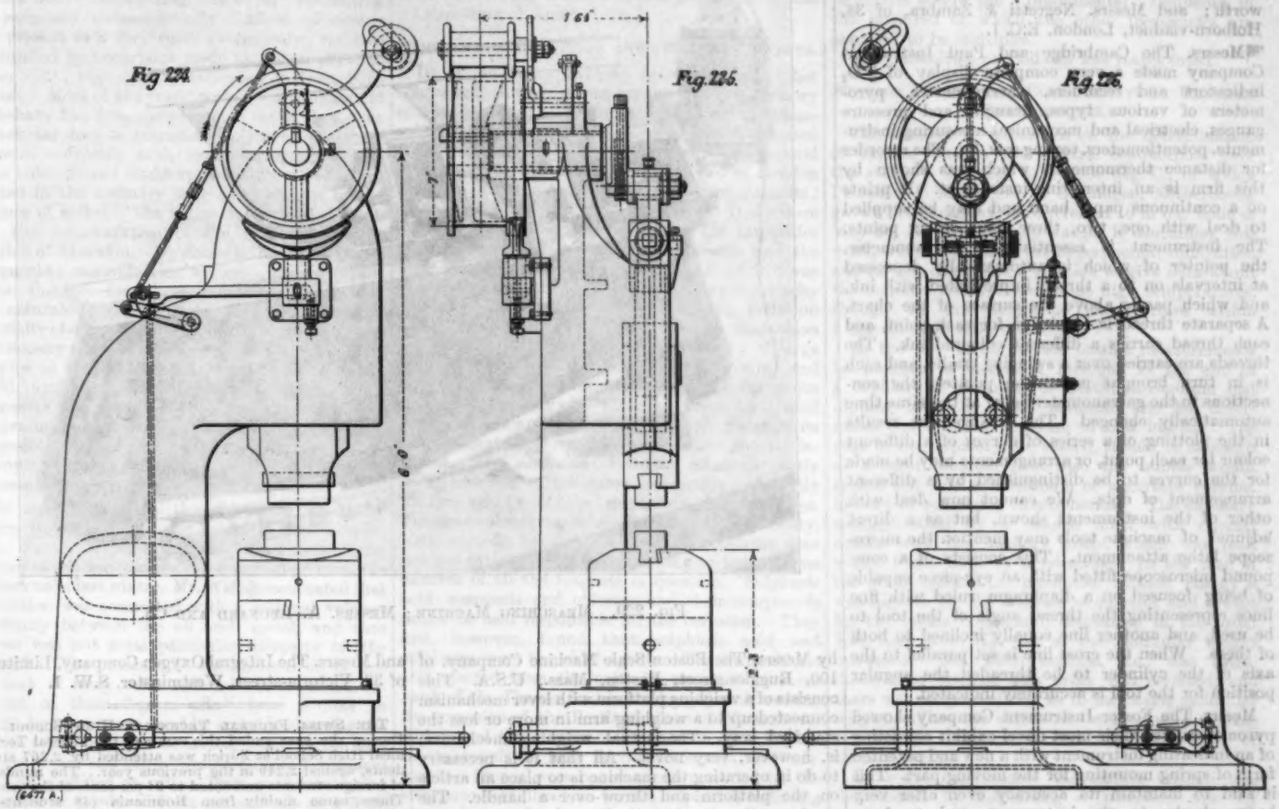


Fig. 223. Portable Petrol Driven Air Compressor Plant; Messrs. The Consolidated Pneumatic Tool Company, Ltd.

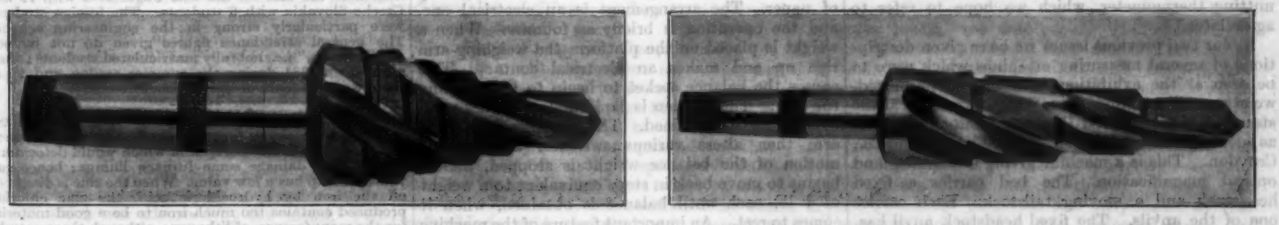
Small Tools.

The small tools exhibit were too numerous for it to be possible for us to deal with them in detail. The few we are able to mention must be taken as representative of a very much larger display,

in which the well-known manufacturers and also the leading steel makers were fully represented. Many firms had demonstration machines on their stands for the purpose of displaying their cutters, drills, &c., to greater advantage. Messrs. E. G. Wrigley and Co., Limited, Birmingham, exhibited "Leader" brand high-speed twist drills, and a large collection of milling cutters, gear cutters, &c. The firm also showed high-speed stocking cutters, hobs, and the usual classes of cylindrical cutters, with shell end mills, end mills and so on. Hole cluded the B.S.A. inserted oil tube drills, inserted blade milling cutters, self-centering chucks and so on, all, naturally, of the excellent quality and high finish with which the name of this firm is always associated. The firm also showed examples of jigs used in rifle work. As is now well known the B.S.A. Company undertake the design and manufacture of jigs for all kinds of purposes as part of their business. The Brooke Tool Manufacturing Company, Limited, of Greet, Birmingham, and several other firms also had a large number of high-



Figs. 224 to 226. 200-Lb. Belt Driven Hammer; Messrs. Bretts Patent Lifter Company, Ltd.



Figs. 227 and 228. Robertson's Stepped Twist Drill; Messrs. Alfred Herbert, Ltd.

and shank reamers were also displayed. Messrs. Lehmann, Archer and Co., Limited, 5, Farringdon Road, E.C. 1, had a well arranged exhibit of small tools such as taps and dies of the various threads now in use, in sets and otherwise, also die nuts, chasers and so on. We believe we are correct in stating that this firm was the first to make B.A. standard thread screwing tackle, now one of their regular productions. Messrs. A. A. Jones and Shipman, Limited, Leicester, who have gone in largely for small tools of particular lines had a display of tool holders of various patterns. These included different types suitable for different types of tool post, and designed for different sections of tool steel. The firm also had knurling tools, grooving and cutting off tool holders, thread cutters, boring bars, dogs, standard sockets, mandrels and so on, all of excellent finish. The B.S.A. Tools, Limited, Birmingham, had an exhibit of interest which in-class tools and cutters to attract the attention of machine tool users.

The small tools shown by Messrs. Alfred Herbert, Limited, included several interesting ones brought out by Messrs. A. Leonard and Co., Croydon, for whom Messrs. Herbert act as selling agents. Among these was an adjustable square of which the blade is bevelled on both sides. The blade fits on a dowel pin on the shank, and is fixed in place by three screws. Adjustment is secured by two screws and adjusting rods with hardened points bearing on the edge of the blade. Some glass surface plates were also shown by this firm. These are said to be ground optically flat, and are guaranteed to within 0·000025 in. They are made of plate glass from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. thick, their sclerescope hardness being from 100 to 120. They do not distort under ordinary workshops temperatures. They are intended specially for tool-room use, and are made in sizes up to 24 in. by 19 in. Each is carried in a base which is ground true to the glass surface.

A new twist drill being placed on the market by Messrs. Alfred Herbert, Limited, Coventry, is illustrated in two sizes in Figs. 227 and 228, subjoined. This form of stepped drill is on Robertson's patent. The drills are made in three to eight steps of different size, according to the work they are intended to perform. They are primarily intended for boiler and other plate work, condenser tube plates, &c. A great saving in power results from one step passing right through the material before the second begins work, and the comparatively small size of the first step necessitates much less power than would a full diameter drill point. The drills can be used with jigs to the size of the first step, after which the jig may be removed and the operation completed, using these holes as a guide. A very smooth finish may be given by using a final step only $\frac{1}{32}$ in. or so larger than the one before. Some comparative tests for a 2-in. drill of the usual type showed the horse-power used to be 8·67, while with a stepped drill the first step required 5·27 h.p., and the remaining three steps took only 1·97 h.p. and 2·67 h.p., the average for the operation being 3·30 h.p.

Engineering Instruments.

As we have already pointed out, an attempt to deal adequately with the main, machine tool, side

of the Exhibition has taken such a large proportion of our space that it is not possible to deal more than briefly with other features which, although directly concerned with machine-shop practice, cannot be described as machine tools. We would like, however, before concluding to refer to some of the miscellaneous exhibits, and may first say something of the engineering instruments and industrial scientific appliances which were shown by Messrs. The Cambridge & Paul Instrument Company, Limited, of 45, Grosvenor-place, London, S.W. 1; Messrs. The Foster Instrument Company, of Letchworth; and Messrs. Negretti & Zambra, of 38, Holborn-viaduct, London, E.C. 1.

Messrs. The Cambridge and Paul Instrument Company made a very complete display of CO_2 indicators and recorders, thermometers, pyrometers of various types, draught and pressure gauges, electrical and mechanical measuring instruments, potentiometers, testing sets, &c. The recorder for distance thermometers which was shown by this firm is an interesting instrument. It prints on a continuous paper band and may be supplied to deal with one, two, three, four or six points. The instrument is essentially a galvanometer, the pointer of which is automatically depressed at intervals on to a thread impregnated with ink, and which passes above the surface of the chart. A separate thread is employed for each point, and each thread carries a different coloured ink. The threads are carried over a swinging cradle, and each is in turn brought under the pointer, the connections to the galvanometer being at the same time automatically changed. The arrangement results in the plotting of a series of curves of a different colour for each point, or arrangements may be made for the curves to be distinguished by a different arrangement of dots. We cannot now deal with other of the instruments shown, but as a direct adjunct of machine tools may mention the microscope lathe attachment. This consists of a compound microscope fitted with an eye-piece capable of being focused on a diaphragm ruled with fine lines representing the thread angle of the tool to be used, and another line equally inclined to both of these. When the cross line is set parallel to the axis of the cylinder to be threaded the angular position for the tool is accurately indicated.

Messrs. The Foster Instrument Company showed pyrometers, &c., their most novel exhibit consisting of an indicating instrument with a new and patented form of spring mounting for the moving part. This is said to maintain its accuracy even after very heavy shocks to the instrument, and to have eliminated the trouble of broken pivots. Messrs. Negretti & Zambra showed a new form of transmitting thermometer, which we hope to refer to again later.

In our two previous issues we have given descriptions of several measuring machines which were to be seen at the exhibition. In Fig. 229, annexed, we give an illustration of one which was shown at the stand of Messrs. Alfred Herbert, Limited, who act as agents for the makers, Messrs. A. Leonard and Co., Croydon. This is a machine giving mechanical and optical magnification. The bed carries a fixed headstock and a moving tailstock. Each carries one of the anvils. The fixed headstock anvil has, at its opposite extremity, a knife-edge in contact with a bell-crank lever. This controls the movement of a rotating mirror on which a cross-wire is focussed, projected from the lamp on the left of the instrument. From the mirror the wire is reflected on to the long scale shown at the back of the machine. The tailstock anvil rests on a ball in the bottom end of the adjusting screw. This anvil is held back by a strong spring, light springs also being applied to the headstock anvil and to the mirror, to eliminate backlash. A lifting table is provided to take the weight of heavy pieces, having screw and rack vertical adjustment. The machine will measure lengths up to 12 in. The measurements are made against standard calibrated rods and blocks. The former are spherical ended. In operation the image is set to the calibrated length on the scale, and the length of the piece to be measured obtained from the reading on the scale, after substituting it for the calibrated rod. An accuracy within 0·0005 in. is guaranteed by the makers when the seal locking the cover enclosing the amplifying gear is not broken.

Miscellaneous Exhibits.

In conclusion, there were one or two miscellaneous exhibits we would like to mention. Among these is the automatic weighing machine which was shown by Messrs. The Boston Scale Machine Company, of 100, Ruggles-street, Boston, Mass., U.S.A. This consists of a weighing platform with lever mechanism connected up to a weighing arm in more or less the standard way. The actual weighing mechanism is, however, very novel. All that it is necessary to do in operating the machine is to place an article on the platform and throw-over a handle. The machine them automatically takes the weight, records it on an indicator on the front of the machine, and at the same time prints it on a travelling strip of paper. The arrangement is an electrical one, and the operation is briefly as follows:—When a weight is placed on the platform the weighing-arm tips up and makes an electrical contact. This causes the balance socket to begin to travel along the arm. This motion is rapid and continues until overbalance is obtained. The rocking-over of the arm then alters various switches, the forward motion of the balance weight is stopped, and it begins to move back in steps equivalent to a weight of 1 lb. each until balance is obtained, when it comes to rest. An important feature of the machine is that it is not necessary for the balance weight to travel back to zero between each weighing. If a series of articles of approximately similar weight is dealt with the balance weight simply moves a short distance to and fro on the arm obtaining the various balances. This greatly adds to the rapidity with which weighing work can be carried out. The machine will weigh articles of from 5 lb. to 5,000 lb. accurately to one pound. It can, of course, be used by unskilled labour, and it is practically impossible to get a weight wrong.

As this weighing machine is more or less an electrical device, we may follow on from it to a mention of one or two of the electrical exhibits, such as that of Messrs. The Electrical Apparatus Company, Limited, of Vauxhall Works, South Lambeth-road, London, S.W. 8. This firm showed various examples of their manufacture, including A.C. and D.C. gear suitable for machine-tool control. The same type of apparatus was exhibited by Messrs. The Igranic Electric Company, Limited, of 147, Queen Victoria-street, London, and Bedford. Magnetic separators were shown by Messrs. The Rapid Magnetting Machine Company, Limited, of 48-52, Lombard-street, Birmingham, while cutting or welding materials and appliances were to be seen on the stands of The Alloy Welding Processes, Limited, of 14-16, Cockspur-street, London, S.W. 1, and Messrs. The Integral Oxygen Company, Limited, of 38, Victoria-street, Westminster, S.W. 1.

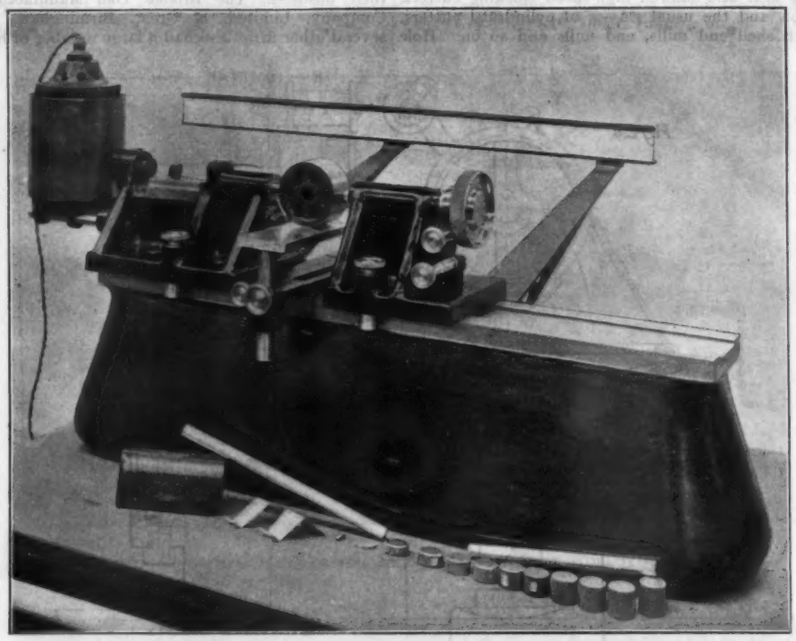


Fig. 229. Measuring Machine; Messrs. A. Leonard and Co.

The Swiss Federal Technical High School.—During the year ended this summer, the Federal Technical High School at Zürich was attended by 2,267 students, against 2,249 in the previous year. The number of foreign students amounted to 24 per cent. of the total. These came mainly from Roumania (48 students), France (47), Italy (44) and Norway (40). Hungary and South America each sent 35 students, Germany and Russia 30, Greece 19, Great Britain 15, and Austria 14, but there are also on the lists Jugoslavia with 19 and Czecho-Slovakia with 6 students. The foreign students were particularly strong in the engineering schools. The general attendance figures given do not include the "hearers," i.e., not fully matriculated students; their number was 381 during the summer session and 95 of them were students of the Zürich University.

Zinc Oxide from Galvanised Iron in Siemens Furnaces.—Siemens-furnace men do not like to have to deal with zinc-coated scrap iron which would deteriorate the iron and damage some furnace linings; hence galvanised scrap has a low value. When the zinc is dissolved off the iron by hydrochloric acid, the zinc chloride produced contains too much iron to be a good material for the manufacture of lithopone although there may be a good deal of zinc in the iron. R. W. Müller, of Witten, Westphalia (*Stahl und Eisen*, September 19 last), found up to 17 per cent. of zinc on iron pails, whilst the electrolytic zinc coating of wire amounted to only 1 per cent. of the iron. Taking 8 per cent. of zinc as an average figure for galvanised iron, it should be profitable to recover that zinc. Müller describes his open-hearth furnace designed for this purpose. The furnace is of the ordinary type, but is provided with bridge extensions at both ends and with valves which can cut the furnace off from the flue and connect it with the cooling and condensing plant and the suction fan of this part of the plant. The furnace is first charged with ordinary scrap; when this scrap has been melted and the furnace is thoroughly hot, the zinc-scrap is added, after operating the valves mentioned. Through the bridges the zinc oxide vapours enter special chambers in which the vapours can expand. They are then drawn through a system of iron pipes in which they are cooled (by the atmosphere) down to 150 deg. C. before they pass through the fan and into the dust flues, which are provided with baffle plates, and the bag filters. There is no mention of electric precipitation of the finest dust. The impure coarse zinc dust collecting in the iron pipes is sold to zinc smelters; the finer, purer oxide from the bags is utilised as zinc white. In the 15-ton furnace the zinc volatilisation carried out by the process above described takes about 2 hours.

THE BRITISH ASSOCIATION.

(*Concluded from page* 416.)

Section B.—Chemistry—(*concluded*).

Lubrication.

The discussion on lubrication was opened by Dr. A. E. Dunstan, who, in a note on "The Chemical Nature of Mineral Lubricating Oils," by himself and Dr. Thole, admitted that 'our present knowledge of the constitution of the hydrocarbons comprising mineral lubricating oils remained extraordinarily limited. Paraffins were present to a very small extent only; reactive unsaturated hydrocarbons made up 20 per cent. to 40 per cent., non-reactive saturated hydrocarbons the rest. Most of the unsaturated constituents did not behave like true olefines, in so far as they gave a black tar (not a colourless polymer) with concentrated sulphuric acid, reacted sluggishly with iodine chloride and could apparently not be hydrogenated in the ordinary way by hydrogen in the presence of nickel. The iodine values varied much with the concentration of the reagent and the duration of its action. Dr. Dunstan hence suggested a somewhat unstable ring system—instead of the olefine linkage—for these reactive constituents. The saturated hydrocarbons seemed to consist essentially of naphthenes (polynuclear compounds) of low viscosity and low lubricating efficiency (Maberg). In order to obtain a good lubricant the oil refiner should carefully regulate the acid treatment so as to remove oxygenated compounds and the most reactive unsaturated compounds which were chiefly responsible for gumming and carbonisation, whilst destroying only a minimum of the more stable unsaturated compounds of lubricating value.

The contribution to the discussion made by Messrs. Henry M. Wells and James E. Southcombe, M.Sc., on "Lubrication and the Germ Process," ran on lines which are familiar to our readers from the discussions of last winter. Mr. Wells accentuated that lubrication was connected with a residual valency or affinity between the oil and metal, and that oiliness was not some particular property of the oil itself. The presence in the mineral oil of one per cent. of fatty acids reduced the frictional coefficient of their "germ oils" from 0·0084 to 0·0052, by 26 per cent., and by suitably choosing the type of fatty acid, the behaviour of oil in the presence of water and other contaminating substances could be modified at will. Thus good lubricating oils could be produced from mineral oils at a little extra cost, and the fatty acids wanted for this purpose were the commercial acids unsuitable for food, whilst the mineral oils used in the germ process were the thin oils of the cheaper kinds.

Mr. H. T. Tizard, of Oxford, referring to the work of Langmuir and Hardy, said that there was evidence, though not decisive evidence, that a layer of oil one molecule in thickness was sufficient for lubrication. He himself thought that the layer should be thick enough to prevent molecular attraction between the two metallic surfaces. In the Wells-Southcombe process there would be a layer of one molecule of fatty acid on each surface of the lubricant which was adsorbed by the metal. [We would here draw our readers' attention to the paper by Dr. Wells on "Thickness of Stratified Films," which was read in Section A and dealt with by us on page 383 *ante*.] As regards the measurements of interfacial tensions Mr. Tizard had found that, when he allowed mercury to drop through castor oil, the drops collected intact at the bottom of the vessel, whilst mercury drops falling through glycerin coalesced rapidly and hence were not separated by a film of oil which would keep them outside the range of molecular attraction. Now glycerin was no good as a lubricant, but castor oil was, though both had practically the same viscosity; viscosity had little to do with lubrication, and interfacial tension was not a guide as to lubricating power. In reply to Mr. Southcombe, who asked whether the castor oil had been acid-free, Mr. Tizard added that the oil was the best obtainable.

Mr. S. R. Illingworth said that in testing refinery oils from various parts of the world, he had frequently observed a decided reactivity—sufficient to dissolve 2 per cent. of copper—in oils which were free from sulphuric acid and from sulphonates; this reactivity he ascribed to naphthenic bodies, and it was noteworthy that such reactive oils also had a large temperature range of lubricating power.

Carbon Determination.

The new "Method of Estimating Carbon by Combustion in Organic Substances when available only in Minute Quantities," which Dr. R. V. Stanford, of Cardiff, described, aims at perfection in analytical practice which requires further elaboration. Dr. Stanford had a similar paper also on the "Estimation of Amno-Acids."

Atmospheric Pollution and its Measurements.

Dr. J. S. Owens gave an account of researches conducted during recent years by an advisory committee of the Meteorological Office on Atmospheric Pollution. The 27 stations distributed all over the country, he stated, recorded in general an improvement, but four stations, two in London and two in Glasgow, reported increased deposits; Westminster enjoyed an alpine peak atmosphere compared with Sheffield, however. The impurities differed much also with time, the season and the hour. Between midnight and 6 a.m. little dust was deposited; with the lighting of the fires the impurity increased up till about 11 a.m.; the pollution varied little afterwards, till the night diminution set in after 10 p.m. The dust consisted of large soot particles, coming down like the rain, and extremely fine particles which pervaded our rooms and could hardly be filtered. They had tried various filters and were ready to supply instruments at a moderate cost; Cardiff should have one, for instance. The corrosion of stone, &c., was partly to be ascribed to the gases or vapours and partly to the acidity of the suspended dust particles. The determinations, especially of the latter acidity, were exceedingly difficult, and the problems were not yet satisfactorily solved, owing to the extreme dilution of all the reagents in question. Sulphuric acid, ammonia and chlorine and their compounds might be held responsible for the corrosion. They had, however, found that sulphuric acid and sulphates were the chief agents. The hydrochloric acid ejected from the potteries near the southern bank of the Thames had been charged with causing the corrosion of the Portland stone of Westminster Abbey and the Houses of Parliament; but experiments acquitted both hydrochloric acid and ammonia. Stones were not so much corroded by the sulphuric acid direct as by the sulphates, including ammonium sulphate into which the acid was converted by the dust. The chief indicators they used were indigo, carmine and methyl orange; Congo red was also sensitive to carbon dioxide, and therefore unsatisfactory.

Mr. Heycock opened the discussion on the subject by putting questions as to the corrosive chemicals. The importance of the work was emphasised by Sir Napier Shaw. Mr. William Thomson, of Manchester, in describing his own method of dust estimation, pointed out that glass apparatus (Dr. Owens had spoken of glass) was unsuited for such estimation; silica vessels should be used. Professor Desch considered the action of hydrochloric acid probable and referred to the decay of some harbour buildings at Liverpool, which might be connected with the fumes from the chemical works at St. Helens; but Dr. Owens had not found any evidence of chlorine action in corroded stones. Free sulphuric acid might be present in fogs, but this was a matter which they had not yet sufficiently investigated.

Absorption Spectra of Organic Compounds.

The main conclusions of the report of the committee dealing with this subject, which is drawn up by its secretary, Professor E. E. C. Baly, of Liverpool, are the following:—

Every elementary atom possesses one or more characteristic frequencies; the molecule of atoms of different elements is endowed with a frequency which is the least common multiple of the frequencies of the respective atoms; these molecular frequencies are also characteristic, since they persist down to low temperatures, and the molecular frequencies in the visible and ultra-violet spectrum are multiples of a fundamental frequency in the infra-red. These conclusions are explained, in accordance with the quantum theory, on the assumption that the electromagnetic force fields of the atoms are condensed in the molecules. The report tabulates the copious literature on the subject which has accumulated since 1916.

After consideration of the report it was resolved to appoint Professor Baly chairman of a new committee dealing especially with the study of infra-red spectra, the extreme importance of which has long since been generally recognised, though not all the physicists accept the "fundamental" frequency in the infra-red of which the other frequencies are assumed to be multiples.

The Committee on Colloids was reappointed.

Surface Tension and Conductivity at Extreme Temperatures.

The remarkable researches on the determination of surface tension and electric conductivity over the range − 100 deg. to + 1600 deg. C., of which Professor F. M. Jaeger, of Groningen, Netherlands, gave a brief account, were referred to in our issue of May 24, 1918. Professor Jaeger is continuing this work, which involves great experimental difficulties, and he was not yet in a position to give data about the conductivities of metals at high temperatures, though he can determine temperatures within 1 deg. C. near 1500 deg. C.

In the case of his surface tension measurements he produces a bubble of nitrogen at the end of a capillary of platinum or platinum-rhodium just dipping into the fused material, and he determines the bursting pressure of this bubble. The edge of the capillary, he stated, should be as sharp as a razor, because otherwise the bubble would spread out into a mushroom of uncertain volume, instead of remaining hemispherical. The capillary communicated by a branch filled with normal octane with the mercury gauge, which was read within 0.001 mm. by a telescope. In the case of the alkali halides the molecular surface energy μ was highest for the fluorine compound and lowest for the iodine compound, decreasing in the order KF, KCl, KBr, KI, i.e., as the molecular weight increased. But when fluorine, &c., was introduced into benzene this order was reversed, and there was no general rule as to increasing molecular weight. When the values of μ were plotted against temperature, the curves were straight lines or slightly curved.

In some experiments the surface tension was determined by suspending a platinum disc by a platinum wire in the fused material; though that wire, itself attached to the chemical balance, was 1 m. long, it was difficult to keep the heat of the crucible away from the balance, even when a water jacket was interposed. The conductivity measurements were still more difficult, because all insulating materials failed at high temperatures, and the exact centring of the inner electrode within the outer ring electrode (all of platinum) was a matter of great delicacy; the Kohbrausch telephone method was used, but the induction coil in the telephone was replaced by a Vreeland oscillator (of Messrs. Leeds and Northrup). Testing salts like potassium tungstate and molybdates at temperatures up to 1625 deg. Professor Jaeger had found the conductivity curves to be straight lines, proving that these electrolytes must be simple in structure, an important conclusion.

Mr. Heycock and others dwelt upon the importance of such work which, Sir William Pope pointed out, would best be left to one or two laboratories open to all competent men.

Coal and Iron in South Wales.

We may mention here a few papers contributed to discussions on the coal and iron industries of South Wales, held in the Geography Section E. Dr. A. E. Trueman, of Cardiff, dwelling upon the important influence which the iron trade had had upon the development of the coal field, said that the iron ores were of two types, hematites, of local occurrence, and the more important ironstone nodules, of more general distribution in thin layers between the shales of the coal measures. The nodules had been worked at the outcrops by scouring, and as the dip of the coal field was very steep in the south, the nodules were chiefly obtained along the northern slope; the north-eastern part of the field at Merthyr

Tydfil remained the centre of the industry. The output of ore had decreased during the latter part of the nineteenth century, and at present most of the local ore was smelted in Staffordshire; the ironstones, moreover, were too phosphatic for steel making, so that Spanish ores were introduced.

Mr. D. Llenfer Thomas, dealing with the distribution of the population on the coal field, pointed out that, up to the middle of the last century, coal mining in South Wales remained subsidiary to iron making. After the iron industry had reached the Rhondda Valley in the 'fifties, the population of Merthyr Tydfil increased in forty years, from 1871 onwards, by 273 per cent., the density of the population in the lower Rhondda Valley now being 26,240 people to the square mile.

Mr. S. Roy Illingworth, of the School of Mines, Treforest, referred in his paper on the coalfield to geological features and to the classification of coal according to C. A. Seyler; he also summarised the important work on coal research done at Treforest.

Science Applied to Public Services.

The conference on "Science Applied to the Public Services," over which the President of the Association, Professor A. W. Herdman, presided, was the outcome of a resolution passed last year at Bournemouth to urge upon the Government, and upon Cabinet Ministers personally, the necessity of organising a scheme of scientific research. The conference was held on the Thursday of the meeting, August 26th, at 5 p.m.; and although meetings had been in session since 9 a.m. that day, Mr. F. E. Smith, F.R.S., director of the Admiralty Research Department, who attended by desire of the Admiralty, was able to address a very full meeting of leading members from all the sections. Remarking that the Association could help both by pointing out defects in the organisation they had adopted, and by giving the sadly-needed moral support, Mr. Smith stated that his position was one of great responsibility, though all proposals were brought before the Advisory Council of the Admiralty, on which Sir R. T. Glazebrook and Sir A. Schuster had seats, besides official members. Nearly all naval research could usefully be initiated on land before being taken on board, where expenses might become very heavy. Their scheme aimed at a land laboratory and an establishment for sea work. They were at present training a naval staff of 28 scientific members who had a card index of all literature on the subject at their disposal. The director was empowered to arrange for special work to be carried out by private individuals and to grant financial aid for such work; such an arrangement had already been made in five cases. As regards big problems, the Research Department was ready to co-operate with scientists in promoting a new Challenger expedition, which the President had demanded in his address, and which the Association subsequently recommended by a general resolution; Mr. Smith added that he did not speak for the Admiralty in this matter. There were great difficulties, especially with respect to the overlapping of researches by different departments, but the Research Department was going to do its utmost to encourage the carrying out of the work necessary.

A prolonged and necessarily somewhat discursive discussion followed. Professor C. F. Jenkin (Section G) outlined the similar scheme adopted in the Air Ministry; he dwelt upon the importance of interesting the colleges in their researches and upon the difficulty of finding the competent first-class man for a particular investigation. Other speakers expressed the same anxiety, which the public may share to even a fuller extent. Professor Barcroft (Physcology; during the war in charge of the gas warfare station at Porton), Sir Robert Robertson (Woolwich), and Dr. J. W. Evans (Geology; adviser on petroleum to the Colonial Office), mentioned how they had worked in other departments. Professor Stanley Gardiner (Zoology) thought that young naval officers should be given facilities for university studies and agreed with others that the position of the first-class research workers should be made more influential and secure. Professor Bone pleaded for fuel research which should not be all centred in a London laboratory; and Dr. F. A. Bather (Geology) drew attention to the fact that the Natural History Museum could do much useful work, and had done so, but it was frequently asked the same question over again by all sorts of Government departments.

Evening Discourses and Citizen Lectures.

Two evening discourses were given, one by Sir R. T. Glazebrook on "Some Requirements of Modern Aircraft" (with which we shall deal in another issue), and the other by Sir Daniel Hall, F.R.S., on "A Grain of Wheat from the Field to the Table." Warning his audience that food supplies were running short, Sir Daniel said that mummy wheat was a myth, and that wheat, improved not by selection of seed grains, but by crossing, could now be grown even on poor soil if strong enough to stand up in rain and wind and against weeds. They were now experimenting with machines that would sow economically—a remark which should interest engineers.

Three Citizen Lectures, open to the public generally, were also delivered, namely, on "Light and Life" by Professor J. Lloyd Williams, of Aberystwyth; on "Present Industrial Conditions," by Professor A. W. Kirkcaldy; and on "The Geographical Position of the British Empire," by Dr. Vaughan Cornish.

Concluding Remarks.

The attendance of 1,378 members of all classes did not reach the figure 1,497 of the Cardiff meeting of 1891, nor the 1,471 of last year's meeting. Considering existing circumstances, however, the attendance must be regarded as satisfactory, and the sections with which we have more fully been dealing, especially A and G, were certainly of high interest and exceedingly busy. The same remarks apply equally to most of the other sections. Yet there was a regrettable, though not unexpected, falling off in the attendance of old members. The recent raising of railway fares and the increased cost of living are partly responsible, and it is to be feared that things will hardly improve by the time Sir Edward Thorpe takes the chair at Edinburgh next year. But that meeting fortunately will once more be a full week's meeting, from Wednesday, September 7, to Wednesday, September 14, and though some critics, without and within the Association, scoff at the pick-nicking element supposed to be connected with the week-end excursions, it stands to reason that members, especially members with families, will hesitate to make a long journey across the country for attending a meeting at which everything is crowded within four days. Exceptional conditions had this year rendered the short meeting necessary; but those who advocated it as the proper course for a scientific meeting by contrast to the popular gathering, took a narrow and erroneous view.

The grants made this year for committee work quite come up to the usual figure, about £1,100. Section A receives £115 (for researches connected with seismology, tides, gravity at sea, calculations of mathematical tables, and chemical tables of constants); Section B, £105 (for the committees on colloids, fuel economy, diazonium salts and absorption spectra); and Section G. £250 (for researches on complex stress distribution and on gaseous explosions). The sections dealing with zoology and anthropology also receive substantial grants. These figures do not comprise allowances made from the Caird Fund of the Association, nor the definite grants for which the Association will apply to the Department for Scientific Research and other public bodies. A successor to the late treasurer, Professor John Perry, has not yet been appointed; Sir Charles Parsons succeeds the late Lord Rayleigh as trustee.

We have already mentioned that the Association will reassemble at Edinburgh on September 7, 1921. For 1922 an invitation to Hull has been accepted, and Canada will be glad to entertain the Association once more (for a fourth time) probably in 1924.

Electric Trains through the Mt. Cenis Tunnel.—The first electric trial train was run between Torino and Bussoleno in the second week of September. This completes the electrification work on the Mt. Cenis line, which, we may mention, is being worked by three-phase current of 3,000 volts.

THE TILLING-STEVENS MOTOR-CAR WORKS.

On Tuesday last we had an opportunity of inspecting the works at Maidstone, Kent, of Messrs. Tilling-Stevens Motors, Limited, whose principal product is their well-known 3-ton to 4-ton petrol-electric chassis for omnibuses, chars-à-bancs, fire service vehicles, electric welding plants and other moderately heavy road traction work. The works are situated on the Medway, between the East Station on the Mid-Kent line, and the Barracks Station on the North Kent line of the South-Eastern and Chatham Railway, so that good facilities exist for both rail and water transport. The main building which was commenced in 1916 and opened last year, is a ferro-concrete structure, having four floors above the ground level and an erection on the roof used as a hardening shop. A separate single-storey building on the opposite side of the road, the firm's original machine shop, is now used for body work and also as a store for rough and finished parts. The works have a total floor area of 190,000 sq. ft., employ about 1,200 men at the present time, and are capable of producing about 40 chassis per week. In another part of the town a building has been acquired and adapted for use as a works club and a hostel for accommodating 25 apprentices.

In general the sequence of the work is from the top of the main building to the bottom, and in briefly describing the works it will be convenient to follow this order. The hardening shop, as above mentioned, is a roof construction equipped with gas-fired furnaces for case-hardening gears and other parts, and also for the heat treatment of steel. Oil and water quenching tanks, and a sand blast plant, are also provided. On the top floor are situated the tool room and tool stores, machine shops for general work, inspection department, plain grinding department, and the laboratories, which include equipment for chemical and metallurgical tests as well as for tests on the strength of materials. For the latter purpose a 50-ton Olsen tensile testing machine and an Avery impact testing machine are installed. The third floor accommodates the progress department and machine shops for finishing engine parts, gears, axles, &c., a separate section of the shop being devoted to each particular part. The finished parts are transferred to the floor below, which is used mainly for the erection of mechanical units, but is partly occupied by a first-aid department, millwrights' shop, and a small printing plant for the production of various cards and forms required in the works. The correspondence office is also situated on this floor, while the general offices are on the first floor, which is, however, mainly used for the production of electrical equipment throughout. Practically all the plant necessary for the work is installed on this floor, only the heaviest machining being done in the machine shops above. For electric welding a motor-generator composed of machine frames similar to those used on the firm's motor vehicles, but with special windings, is employed in this department. The main drawing office, in which about 24 draughtsmen are employed, is also situated on this floor.

A considerable portion of the ground floor, which is larger than the upper floors, is used for the erecting shops, which can accommodate about 40 chassis at a time. At the time of our visit 21 chassis were in the course of erection, and we were informed that these would be running on the road by the end of the present week. Most of these vehicles were of the petrol-electric type, but the firm also produce a 2½-ton gear-driven model which accounts for some 20 per cent. of their output. Frames constructed of pressings obtained from outside manufacturers are also built up in a shop on the ground floor equipped with five smith's hearths and an electrically-driven pneumatic power hammer. Before delivery to the erecting shop the electrical equipments are carefully tested, and each engine is thoroughly run in and tested on the brake in a large and well-equipped test room. Air brakes and Froude hydraulic dynamometers are used for this purpose, and, in some cases, generators supplying power to the mains are used as a load for the engines.

The main power supply, however, is obtained from the town mains in the form of alternating current at 6,600 volts pressure. The energy is transformed by static transformers and motor generators into direct current and distributed throughout the works by the three-wire system, at a pressure of 440 volts across the outers. Many of the tools are driven in groups by short lengths of line shafting arranged across the shops on both sides, leaving a central gangway. A separate motor drives each length of shafting, the motors being suspended over the central gangway.

The main stores are situated on the ground floor, and material is distributed from them to stock bins on each floor for use as required. For distribution, 1-ton electric trucks are used, the trucks being raised to the upper floors by means of electric lifts. One of these has a lifting capacity of 5 tons and is sufficiently

large to handle a 2½-ton chassis complete. Lubricating oil and cutting compounds are stored in tanks on the ground level and pumped up to the upper floors, and turnings and swarf from the machine tools are dumped through a vertical chute outside the building into a brickwork compartment built under the chute in the yard.

In general it may be stated that considerable care and forethought has been exercised in laying out the works, which, although not designed for production on a colossal scale, are nevertheless of interest as an example of a modern plant intended to produce a high-class and rather complicated machine on economical lines. With some of the firm's more recent productions we hope to deal on a future occasion, but reference may here be made to a Tilling-Stevens petrol-electric fire engine with a detachable electrically-driven pumping unit, which was illustrated and described in our issue of February 6 last, on page 173.

INDUSTRIAL NOTES.

The verbatim report of the twenty-first annual general council meeting, held at Leamington on July 1 and 2, states the following, under the heading "44-Hour Week": Mr. Hill, secretary of the Boilermakers and Iron and Steel Shipbuilders, said: ". . . I have lately been in communication with one of the largest machine makers in this country, supplying this country and the trade all over the world. He welcomes the idea of the 44-hour week. The more the hours are shortened the more we shall introduce machinery, and we shall simply put our brains and ingenuity into this machinery in order to make it do a greater part of the work than we have been able to do when we have been working longer hours." (Here Mr. Crinion, Card and Blowing Room Operatives, Amalgamated, interposed: "If you can establish that you will find me a strong supporter of it.") Mr. Hill, continuing, said: "I know that in our own industry we have introduced machinery in the last few years which can double the output of any man's work. We are wanting relief from laborious toil, and whilst we are willing to work long hours the employers will let us work them and will not spend good money on machinery and plant to relieve us . . ." This statement by Mr. Hill is welcome. We are afraid that many unions have in the past rather opposed than otherwise any development in the use of labour-saving machinery.

The fifty-fifth annual general meeting of the Palmers Shipbuilding and Iron Company, Limited, was held at Newcastle-on-Tyne on Friday last, when the chairman, Mr. G. Mure Ritchie, said: "Referring to new tonnage, I emphasise that we as builders have viewed with regret the continued demands made by labour. Such demands, and the attitude of labour generally in reference to production, are also preparing the way for a position of very serious moment for the workmen inasmuch as they are only hastening the return of those lean times which they, not less than ourselves, dread, and in which we shall all suffer. Shipowners generally have ceased to place orders. Some, indeed, have already cancelled contracts, and we are beginning now to hear of empty berths in shipbuilding centres. I have every confidence that, given a fair chance, we can maintain our premier position as a shipbuilding and shipowning nation, but it is idle to disguise from ourselves the fact that we may, by a fatuous policy, destroy that position and allow other countries to take orders British shipbuilders might have had, and freight British shipowners might have carried. I commend to British workmen the example of Belgium, which has long since settled down to steady work, and I believe that the most important districts of Germany—notwithstanding frequent inspired statements to the contrary—have also settled down with intense energy to industrial output. I would fain believe that labour as a whole desires to establish fair and equitable conditions. This aspiration I know is shared by the employers, as is witnessed by the manner in which they have endeavoured to meet the claims of labour. As regards the industrial future, almost everything depends upon the labour position. I have insisted before at these meetings upon the imperative necessity of Capital and Labour working amicably in their common interests, and I would again say that no good can come to either without such an understanding. I am convinced there is ample work in Britain for years to come, and that there need be no unemployment of any willing to do an honest day's work for good pay, but the ca' canny policy of many trade union leaders, and the coal miners in particular, is destroying credit and killing enterprise, and unless changed can bring only disaster on the country and ruin to the workers."

Speaking at the fifty-sixth annual meeting of the Sheepbridge Coal & Iron Company, Limited, held in Sheffield, last Monday, the chairman, Lord Aberconway, said, as regards coal output, the figures of the company were very significant. The total output for the year before the war per man working at the face was 755 tons; in 1919, after the war, the total output per man was only 668 tons. That was a falling off of one-sixth; but when they came to the present year—1920—the output was only 561 tons, or something like 24 per cent. less than it was before the war. That was entirely an affair of the men at the face. It was a remarkable thing that the output during the last twelve months, which, as he had shown, dropped off so seriously, was accompanied by a rise in wages of very nearly 1s. That entirely bore out the argument which Sir Robert Horne and the Prime Minister urged during the recent discussions, and what was true of Sheepbridge was, to his knowledge, true of nearly every other colliery in the country. They must not forget that they were very nearly 50 million tons short of pre-war production. That affected the country in every possible way. It affected their foreign trade food supplies, because every ship that used to take coal out to the Argentine and various parts of the world, brought back foodstuffs and raw materials, and the freight for the double voyage was not greater than the single voyage home now, with the result that the country got its food and raw materials at a much cheaper rate than it could get them to-day with no coal being sent abroad to relieve the situation. That, of course, affected the cost of living for the poorer classes. It restricted the output of ships, and that restricted the output of steel, and that, in turn, restricted the output of iron. The whole thing worked back to the output of coal in the home collieries, and that, he hoped, had now been understood by the leaders of the miners, and he hoped they would try and pull together with the coalowners, not merely for the sake of higher profits for anybody, or for the sake of higher wages, but for the sake of the trade of the country as a whole.

During the time that the railroads were in the hands of the Government, says *The Iron Age*, New York, the efficiency of the workman steadily decreased, and because of the resulting decrease in production in spite of large increases in wages some of the railroads are looking for a reimbursement from the Government for the loss brought about thereby. The Kansas City, Southern Railroad, for instance, has prepared a brief, in which it sets forth the fact that while wages per hour have in some instances increased 100 per cent. or more, the amount of work accomplished in an hour has decreased more than 25 per cent. As examples, it is stated that the job of disconnecting a firebox from its boiler, which took 25 hours before the Government took control, now takes 36 hours; for flanging sheets, the time has increased from 75 hours to 104 hours; and threading staybolts and drilling tell-tale holes from 92 hours to 130 hours. In this brief the Kansas City Southern asks that in fixing the amount of maintenance funds to be paid the railroad, the Government take into consideration "not only the increase in the amount of the wage unit over the amount of the wage unit in operation for the three-year period prior to June 30, 1917, but the decrease in the amount of labour productivity the increased wage unit will purchase at present and has purchased since the Government took over the railroads as compared with the amount of labour production purchasable with the smaller wage unit before the Government took over the rail lines." It is figured that if a favourable ruling regarding this contention were put into effect, more than one billion dollars additional would have to be paid out by the Government to the railroads.

The Industrial League and Council, realising the importance of bringing as much light as possible to bear on the subject of unemployment, devoted last week-end to its consideration. A number of prominent representatives of labour and employers accepted the invitation of Mr. H. V. Roe to spend the week-end with him at Givons-grove, Leatherhead, in order to discuss the problem. The discussion was opened by Mr. H. V. Roe, who read a paper on "Unemployment and Bankruptcy, the Spurs to Progress." Every issue involving unemployment that could be thought of was introduced and debated from the point of view of the employee as well as from that of the employer representatives in attendance—and the conclusions which were ultimately come to were: That this conference of employers and employed after thoroughly discussing Mr. H. V. Roe's paper are of opinion that: (1) Each industry should form a Joint Industrial Council of employers and employed at which all the incidents of unemployment should be thoroughly and scientifically investigated. (2) Each industry should decide whether it is possible for the industry to maintain and supervise its own unemployed. (3) The representatives of all the Joint Industrial Councils should then meet and consider whether unemployment should be settled by each industry or by all industries as a whole.

A conference was held at 10, Downing-street, last Friday, between the Prime Minister, Cabinet Ministers and members of the Executive of the Miners' Federation of Great Britain, following which the latter decided in favour of suspending the strike notices for one week and of meeting the mine owners in the meantime, in order to discuss matters with them. The discussion with the mine owners was to bear on a "datum line" of output as proposed by the Prime Minister, as follows:—

> For an output of x tons the wages would be increased by 1s. per shift;
> For $x + y$ tons they would be increased by 2s.;
> And for $x + y + z$ tons they would be increased by 3s. per shift.

Representatives of the mine owners and of the miners have held joint meetings at the Board of Trade since Saturday last, when Mr. Evan Williams, president of the Mining Association of Great Britain was appointed chairman, and Mr. Robert Smillie vice-chairman.

After the meeting on Wednesday last it was announced that the mineowners and the miners' representatives had failed to arrive at an understanding on the question of wages based upon output. The mineowners proposed that 240,000,000 tons be accepted as a "datum line." It is reported that the miners declined to make this a basis of discussion and insisted upon the granting of their original demand for an increase of 2s. per shift.

Meetings of the miners' delegates are being held to consider the situation.

Mr. J. Hammond, a well-known accountant of Cardiff, states that the average daily output of coal for each person employed for the four weeks ended June 21, 1919, in comparison with the four weeks ended June 19, 1920, works out for the earlier period at 15 cwt. 1 qr. 6 lb., and for this year at 14 cwt. 2 qr. 18 lb., a decrease of 2 qr. 16 lb. It is true that the Sankey award of a seven hours days comes into this year's return, but it was suggested at the time that "the result would, owing to conservation of energy, be an increase of output." But the mischievous effects of falling output are deeper seated, and cover a much longer period of time than the Sankey award. Mr. Hammond adds the following:—"It is usually considered in normal times that the average output should be equivalent to one ton a day for each person employed (surface and underground) and therefore the low average of 15 cwt. 1 qr. 16 lb. for 1919, and of 14 cwt. 2 qr. 18 lb. for 1920, cannot but indicate very forcibly that the men are not working earnestly, or doing their best to help the country by producing as much coal as possible to barter for food and raw materials, and so long as they continue to restrict the output, high prices will be maintained to the detriment of rich and poor alike. Our export of coal is now only 40 per cent. of what it was before the war. Collieries should strain every nerve to increase the output, and to recover our trade while prices are in our favour. It will be too late to cry out when the Americans have captured our foreign markets."

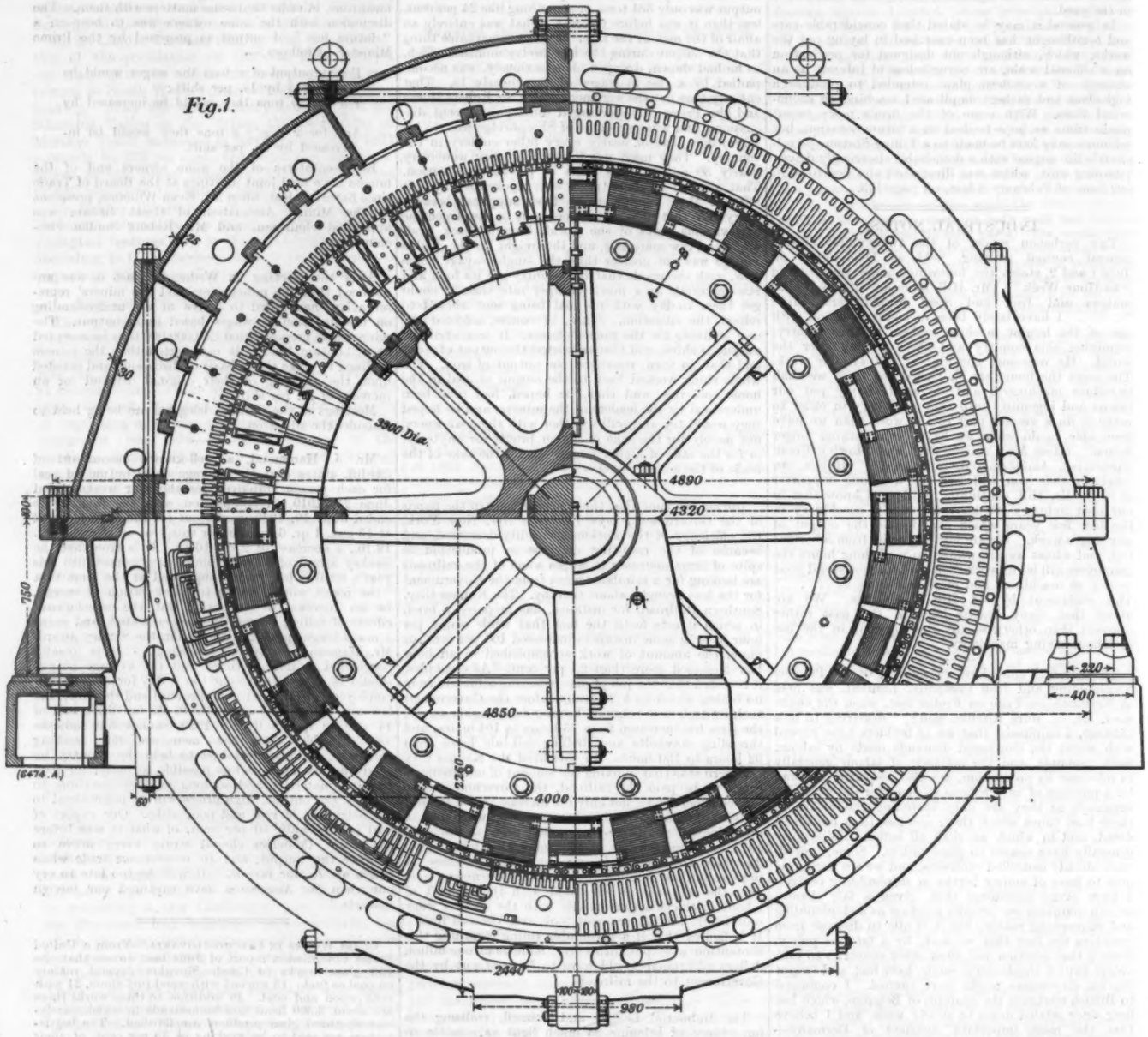
Glass Works in Czecho-Slovakia.—From a United States Commission report of June last we see that the 156 glass works of Czecho-Slovakia depend mainly on coal as fuel; 15 worked with wood fuel alone, 21 with both wood and coal. In addition to these works there are about 3,500 firms and homesteads in which partly-manufactured glass products are finished. The bottle-makers are said to be working at 35 per cent. of their pre-war capacity, and the plate-glass works at 75 per cent. of that capacity, but with an ample supply of coal it is hoped to raise the capacity, to 50 per cent. above the pre-war figure.

The Air Conference, 1920.—The Air Conference called by the Air Council will be held in the Guildhall, London, on the 12th, 13th and 14th instant. The first day will be devoted to civil aviation, lectures on this subject being delivered by Major-General Sir F. H. Sykes and Mr. H. White Smith, in the morning and afternoon, respectively. On the second day, technical aviation will be dealt with, a lecture on Aircraft Research being delivered by Air Vice-Marshal Sir E. L. Ellington in the morning, after which a visit will be paid to the Croydon Aerodrome. Later, after the members of the Conference return from Croydon, a lecture by Capt. F. S. Barnwell, on the technical aspects of aviation, will be delivered at the Guildhall. The subjects for the last day of the Conference will be Service Aviation and Airships, a lecture on the former being delivered by Air-Marshal Sir H. M. Trenchard, in the morning, and on the latter, by Commander Sir Trevor Dawson, in the afternoon. This Conference, the first of its kind to be held, is a function of considerable importance in connection with the future of British aviation, and its proceedings will be followed with interest by all who have the welfare of the aviation industry at heart.

1,750 K.V.A. SLOW-SPEED ALTERNATOR.

CONSTRUCTED BY THE GENERAL ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 1.



A SLOW-SPEED three-phase alternator, embodying many interesting features has recently been manufactured at the Witton Works of the General Electric Company, Limited. The machine in question was constructed to the order of the St. John Del Rey Mining Company in South America, and as its ultimate destination was at a site on the other side of the Andes where the difficulties of transport were very great, it was necessary to design it specially to suit the conditions. The mechanical design was, in fact, governed throughout by questions of transport and erection, and it was not permissible for any single piece to exceed 5 tons in weight. Hence the stator had to be constructed in four sections, and the rotor built up with a separate rim consisting of four steel rings keyed and bolted to the outer ends of the arms. Very complete electrical tests were carried out on the machine before despatch, and these by the courtesy of the General Electric Company we are able to publish together with the description of the alternator.

The rated capacity of the machine was 1,400 kw. at full load, with a power factor of 80 per cent. The terminal pressure was 5,200 volts between phases, and the frequency 50 cycles per second at a speed of 187·5 r.p.m. The line drawings, Figs. 1 and 2, on the present and opposite pages, make the general construction clear, while details of the stator, rotor, field coils and bedplate are given in Figs. 3 to 12. The general appearance of the alternator will be seen in Fig. 22, page 444, which shows it erected on its own steel bedplate in the testing bay of the Witton Works, while the assembled rotor and parts of the stator are shown in Figs. 19 to 21, on the same page.

The stator frame is, as has already been mentioned, built up of four quadrantal cast-iron segments registered together by keys and bolted together at each joint, not only at the flanges but by pairs of long additional bolts which ensure a bearing pressure across the whole of the joint faces and thus eliminate the possibility of vibration or distortion of the frame. Figs. 1, 20 and 21 render the stator construction clear. The rotor consists of a cast-iron spider having a rim comprised of four cast-steel rings. The two inner rings are fastened to the spider arms by set screws and secured by taper keys driven in from opposite sides. The set screws have strong spring washers under their heads, and the dividing plane between each pair of folding wedges is radial to the wheel, so that any strains due to centrifugal force shall not loosen the connection. The poles, which are built up of steel laminations, are dovetailed into the central pair of rings and held by taper keys. The outer pair of rings are spigotted to the inner pair and held to them by set screws in addition. The function of these outer rings is to furnish the necessary weight of rim to produce the required flywheel effect, namely, 1,420 ton-ft. The very solid construction of the assembled rim is well shown in Fig. 19.

The field coils, shown in detail in Figs. 3 to 6, are wound with copper strip on edge with insulating strip between adjacent turns. They are then secured between gun-metal clamping plates. Each complete coil is rigidly fixed to brackets carried on the side plates of the poles by set screws which pass right through to the rim of the wheel and thus prevent lateral movement. A damping winding is secured to the pole pieces by copper rivets. Each section is linked to the corresponding section on the next pole, thus forming a continuous ring around the system.

As the alternator was required to supply current through a 30,000-volt transmission line, a true sine wave form of the voltage, free from ripples, was of great importance. The stator winding had to be

1,750 K.V.A. SLOW-SPEED ALTERNATOR.

CONSTRUCTED BY THE GENERAL ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 2.

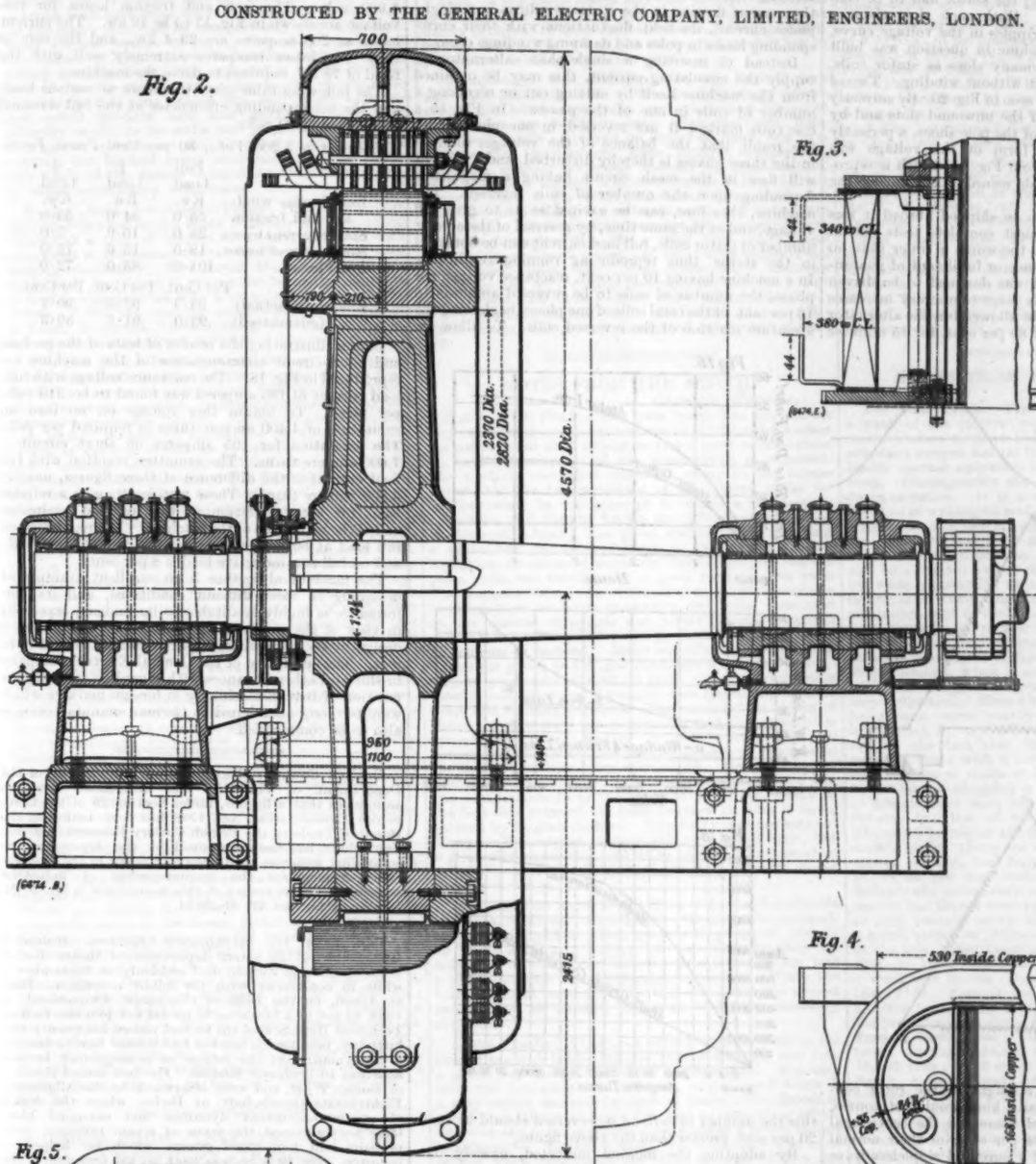


Fig. 3.

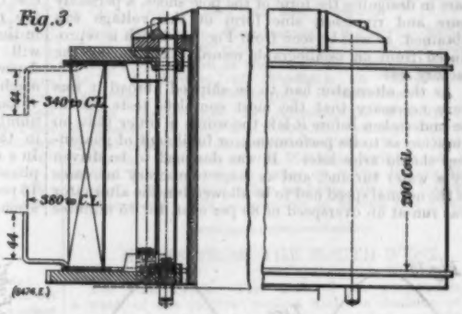


Fig. 7. CROSS SEC. OF ARMS.

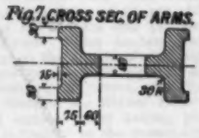


Fig. 8.

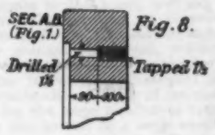


Fig. 4.

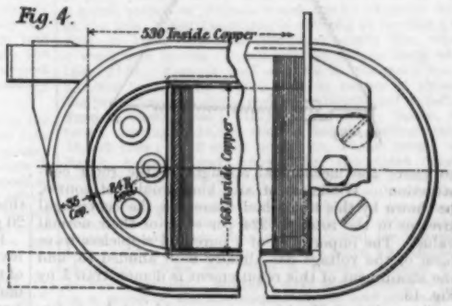


Fig. 5.

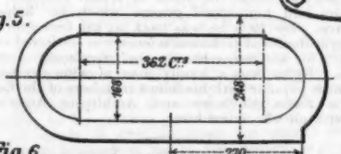


Fig. 6.

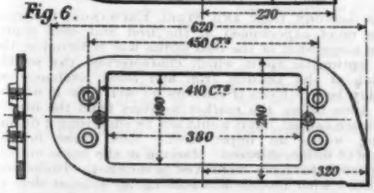


Fig. 9. SECTION OF DOVETAIL KEYWAY.

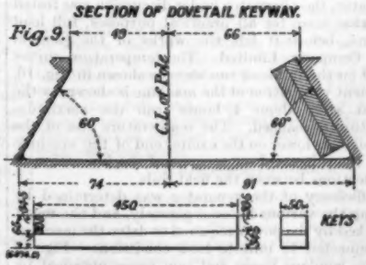


Fig. 10.

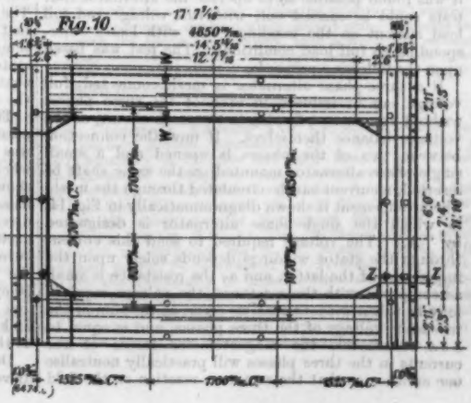


Fig. 11. SECTION THRO' W.W.

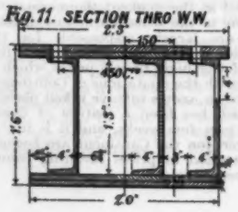
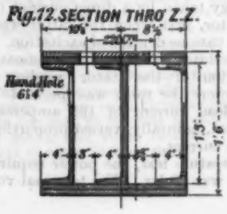


Fig. 12. SECTION THRO' Z.Z.



insulated with seamless mica tubes on account of the high generating voltage, and for this reason, as well as to facilitate repairs on site, the stator had to be constructed with open slots. With such slots there is always a danger of tooth-ripples in the voltage curve, and to avoid this the machine in question was built with more than twice as many slots as stator coils, a few of the slots being left without winding. Two of these unwound slots can be seen in Fig. 20. By correctly determining the number of the unwound slots and by care in designing the form of the pole shoes, a perfectly pure and rippleless sine form of the voltage was obtained, as will be seen from Fig. 13, which is reproduced from an oscillograph record taken during the factory test.

As the alternator had to be shipped abroad it was very necessary that the most complete tests should be undertaken before it left the works in order that no question as to its performance or fulfilment of guarantees should arise later. It was destined to be driven by a water turbine, and as large temporary increases of the normal speed had to be allowed for, the alternator was run at an overspeed of 80 per cent. for 15 minutes

Fig. 13.

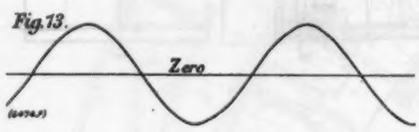


Fig. 14.

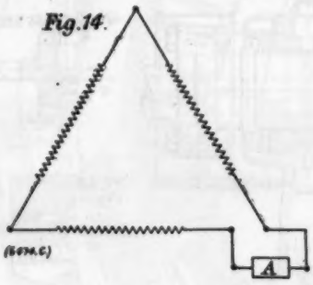
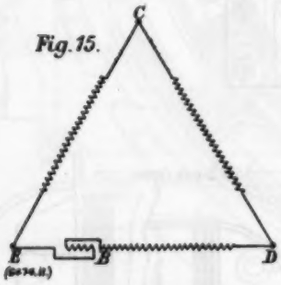


Fig. 15.



to prove the mechanical strength of the rotor construction. Weakness of any kind would, of course, be shown by this test, which increased the centrifugal stresses in the rotor to 324 per cent. of their normal value. The importance of a pure and rippleless wave form of the voltage has already been alluded to, and the attainment of this requirement is demonstrated by Fig. 13.

The ordinary Hopkinson test could not be undertaken as only one machine was available, nevertheless it was found possible so to operate the alternator that tests could be carried out, with full voltage and full load current on the windings, and with losses corresponding to full load conditions. The test was based upon the following principle.

If a three-phase alternator is mesh connected, full voltage can be induced in each of the three phases without any current flowing in the mesh circuit, as the voltages balance themselves. If now the connection between two of the phases is opened and a small single-phase alternator mounted on the same shaft be inserted, a current can be circulated through the mesh. The arrangement is shown diagrammatically in Fig. 14, in which the single-phase alternator is designated by "A." The voltage required to send this current through the stator windings depends solely upon the impedance of the latter, and as the resistance is small as compared with the reactance, the voltage required may be taken without sensible error, as the sum of the reactance voltage of the three phases, and is equal to $3 e x$. Moreover, the magnetometer forces of the currents in the three phases will practically neutralise one another so that the armature reaction on the field due to the stator current is small. The field excitation of the alternator is therefore but little affected by the introduction of the circulating current, and although the current flowing in the stator windings is a single-phase current, no field fluctuations with their corresponding losses in poles and damping windings occur.

Instead of inserting a single-phase alternator to supply the circulating current, this may be obtained from the machine itself by cutting out or reversing a number of coils in one of the phases. In Fig. 15 a few coils marked B are reversed in one phase, with the result that the balance of the voltages induced in the three phases is thereby disturbed, and a current will flow in the mesh circuit having a magnitude depending upon the number of coils reversed. The machine, therefore, can be excited so as to give full voltage, and at the same time, by reversal of the correct number of stator coils, full load current can be obtained in the stator, thus reproducing running conditions. In a machine having 10 per cent. reactance voltage per phase, the number of coils to be reversed amounts to 15 per cent. of the total coils of one phase, neglecting the armature reaction of the reversed coils. To allow for this the number of coils to be reversed should be some 20 per cent. greater than the above figure.

Fig. 16.

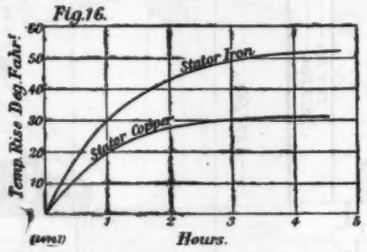


Fig. 17.

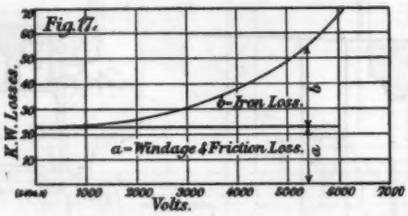
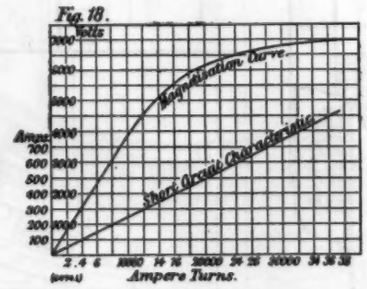


Fig. 18.



By adopting the method indicated, namely, the reversal of a certain number of the coils in one phase of the stator, the alternator under discussion was tested under, what were for all practical purposes, full load conditions, before it left the works of the General Electric Company, Limited. The temperature curves obtained on the full load run were as shown in Fig. 16. The efficient ventilation of the machine is shown by the fact that after about 4 hours' run the maximum temperature is reached. The temperature rise of the stator coils was lower on the exciter end of the machine than on the other end on account of the fan action of the connections between the field coils.

The efficiency of the generator was determined by measuring the various losses separately, and the result was checked by the power required to drive the machine when connected to imitate load conditions. Fig. 17 shows the windage losses and iron losses obtained by measuring the energy taken by a direct-current motor driving the alternator, first when the latter was unexcited and then at various degrees of excitation. The current losses in the stator were obtained by measuring the watt-consumption of the stator winding with 50-cycle current, before the rotor was inserted. The loss with the full-load current of 195 amperes was 28 kw., and the losses, naturally, varied proportionally to the square of the current.

During the temperature test, the power required to drive the generator was 78 kw. The terminal voltage was 2,700 volts mesh connected and the current 200 amperes. The corresponding no-load voltage, allowing for reactance drop and star connection, is 4,950 volts. The iron and friction losses for this voltage are shown in Fig. 17 to be 49 kw. The current losses at 200 amperes are 29·4 kw., and the sum of these two losses compares extremely well with the total of 78 kw. required to drive the machine.

The following table gives the losses at various loads and the corresponding efficiencies at the full terminal pressure of 5,200 volts.

Efficiencies at 5,200 *Volts*, 80 *per Cent Power Factor.*

	Full Load.	¾ Load.	½ Load.
	Kw.	Kw.	Kw.
Iron losses, windage and friction	55·0	54·0	53·0
Stator current losses	28 0	16·0	7·0
Rotor current losses	18·0	15·0	12·0
Total losses	101·0	85·0	72·0
	Per Cent.	Per Cent.	Per Cent.
Efficiency (actual)	93·3	92·5	90·7
,, (guaranteed)	93·0	91·5	89·5

Curves illustrating the results of tests of the no-load and short-circuit characteristics of the machine are reproduced in Fig. 18. The reactance voltage with full-load current of 195 amperes was found to be 316 volts per phase. To obtain this voltage on no load an excitation of 1,400 ampere-turns is required per pole. The excitation for 195 amperes on short circuit is 7,600 ampere turns. The armature reaction with full load current is the difference of these figures, namely 6,200 ampere turns. These test results give a reliable basis for the calculation of the full-load excitation and of the regulation of the machine. The regulation on full load at 80 per cent. power factor is 20 per cent., and on full non-inductive load is 8 per cent.

The machine altogether is an excellent example of designing to meet difficult conditions, and its performance is highly creditable to its makers, especially in view of the constraint imposed upon the electrical design by the mechanical requirements which had to be met. The enterprise of the General Electric Company in this and other instances with regard to securing the position of British machinery in foreign markets which were too long abandoned to German manufacturers is also to be commended.

British Cutlery Research.—The secretary of the Department of Scientific and Industrial Research announces that a licence, under Section 20 of the Companies (Consolidation) Act, 1908, has been issued by the Board of Trade to the British Cutlery Research Association which has been approved by the department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. The secretary of this association is Mr. J. M. Denton, P.O. Box 49, Sheffield.

The late Dr. Huldreich Keller.—Huldreich Keller, chief of the patent department of Messrs. Escher Wyss and Co., at Zürich, died suddenly on September 7, while in conference with his fellow managers. Born at Arbon, on the Lake of Constance, Switzerland, in 1868, as son of a blacksmith, he did not join the Federal Technical High School till he had passed his twenty-first birthday, because his mother had wished him to become a clergyman. At the college he subsequently became assistant to Professor Stodola. He then joined the firm of Escher Wyss, and went afterwards to the Allgemeine Elektrizitäts Gesellschaft, at Berlin, where the design of continuous-current dynamos first occupied him; later he conducted the trials of steam turbines, compressors and high-speed pumps which he helped to improve. By 1909 he was back to his first firm. His degree as doctor of technical science was conferred on him in 1912 for his researches on the calculation of curved plates. Keller was a kindly man of wide sympathies, and most popular with his fellow members of the Council of the Swiss Engineer and Architects Association, and with all who knew him.

The London Iron and Steel Exchange, Limited.—The relief experienced in the iron and steel trades at the suspension of the coal strike was reflected in the more optimistic spirit which characterised the weekly meeting of the London Iron and Steel Exchange on Tuesday last. Even if matters go well now it will be some time before the market recovers from the loss of confidence caused, but it would not be surprising if during coming weeks an improvement took place in the volume of orders released. Buying in the home market is reported to have improved somewhat. Difficulties connected with finance are holding up a great deal of business, and at the moment there seems little prospect of any easing of the situation in this direction. Similar difficulties are largely responsible for the slump in export trade, and in this department foreign buyers complain of the high British prices which compare unfavourably with the quotations of Continental producers. A halt, however, seems to have taken place in the undercutting which has been a feature of Continental sales during the past few weeks, and it is not unlikely that manufacturers on the Continent are becoming alarmed at the depression in prices resulting from competition amongst themselves.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Coal Trade Optimism.—A hopeful view of the coal trade position was expressed by Lord Aberconway in Sheffield on Monday. Having been to some extent in touch with both sides, he knew there was no bitterness on the men's side, and he was perfectly certain he could speak for the owners in saying that they would meet the leaders of the Miners' Federation with a friendly feeling towards them. He expected it would be found that the parties would settle a datum line of something like 240,000,000 tons, which was well below what the men could produce and had produced. The great difficulty would be to settle the proportion of increase of wages in relation to the increased output over the country, but he had every confidence that the skilled men who had this matter in hand would be able to come to some satisfactory conclusion.

Rolling Stock for Siam.—Prince Purachatra, Commissioner-General of the State Railways of Siam, to-day concluded a tour of inspection of the principal works concerned in the manufacture of rolling-stock and road-making machinery. His Royal Highness's visit was made with the object of noting the latest developments in engineering practice with a view to placing extensive orders. "We are making considerable developments in Siam," he stated, "constructing new lines, and trying to improve the transport facilities of the country."

Iron and Steel.—Pending a satisfactory development in the coal trade position, little progress can be made in the movement to re-introduce firm prices for quotations respecting materials, tools and engineering products required by overseas buyers. Current business is therefore largely limited to immediate requirements. The dearth of castings is still an outstanding feature of the heavy sections, and though activity may shrink during the winter months in some of the finished branches, the big foundries are likely to remain well employed on extensive arrears. Railway steel departments are fully occupied with contract bookings. A heavy tonnage of axles, springs, tyres and tubes is going away to the Colonies. There is no actual rush for tramway steel, though many of the provincial corporations are in the Sheffield market for track work and points and crossings. The decline in sales of British-made automobiles is severely felt among local steel makers, a big proportion of whose output has hitherto been absorbed by this industry. Business in tool steel, crucible steel and electric steel is distinctly dull. Scores of lathes are idle. Makers of files and saws do not exhibit anxiety respecting the shrinkage in current inquiries. They are confident that the decline will be of a temporary nature, and that a return will be made to full activity as soon as the air is cleared in regard to labour demands. The call for agricultural implements and machinery parts, joiners' tools and sheep shears, keeps fairly level with the gross output. More orders are being placed locally for the cheaper grades of steel now that prices have deflated. There is a heavy run on acid steel and bar iron. Pig-iron supplies are coming through steadily, though not in large quantities.

South Yorkshire Coal Trade.—Deficiency in output is felt more acutely than ever now that the collieries are holding back stocks to ensure the working of pumping engines and ventilation appliances in case of a stoppage. Works are unable to obtain full tonnages. Railway companies seem to be faring rather more fortunately. Reserves at sidings have steadily increased. The gross output of gas fuels is going inland to meet an exceptionally brisk call. Activity in the house coal section is unabated. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty slacks, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues on only a very limited scale. Foundry kind is once more exceedingly scarce. This quality is not purchaseable for shipment abroad, and the opinion appears to be gaining ground that there is not likely to be much, if any, to spare for export this year. Certainly production up to the present is insufficient to cope with home requirements, and until they are fully satisfied no hope can be entertained of release of foundry iron for abroad. To home customers, No. 3 and the inferior qualities of Cleveland pig-iron are 225*s.*, and No. 1 is 237*s.* 6*d.* Silicious iron is selling for shipment abroad at 277*s.* 6*d.*, and mottled and white is said to be obtainable for export at 230*s.*, but foreign demand for these qualities is very small indeed.

Foreign Ore.—Business in foreign ore is still confined to sales of odd cargoes, but consumers are now giving considerably more attention to offers of sellers, and this raises the hope that renewal of activity is at hand. Rubio, of 50 per cent. quality, is 48*s.* to 50*s.* c.i.f. Tees.

Hematite Iron.—The hematite department presents few new features of moment. Supply is anything but plentiful, and on the other hand both home and foreign inquiries are on only a moderate scale so that the amount of business passing is small. Producers are fully sold over the next month or two, and merchants have not much iron at immediate command, though some of them have considerable quantities to take up. For home consumption, Nos. 1, 2 and 3 East Coast brands are 260*s.*, and No. 1 is 262*s.* 6*d.*; whilst for shipment to France, Belgium and Italy, mixed Nos. are 265*s.* and No. 1 is 267*s.* 6*d.*; and for despatch to other destinations abroad mixed Nos. have been sold at 280*s.* and upward.

Coke.—Coke keeps scarce and very strong. Deliveries to some of the local blast furnaces recently have been barely sufficient to meet essential needs. Average blast-furnace kind is 62*s.* 9*d.* at the ovens, and quality low in phosphorus is 65*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—In the finished iron and steel industries new orders are difficult to secure except for heavy steel rails, and quotations for most descriptions are decidedly easy. Manufacturers, however, keep busily employed on orders on hand, and notwithstanding increasingly keen foreign competition, which is causing no small amount of apprehension, hope that this district will continue to secure its fair share of work in the world's markets. Many works are unable to keep fully going owing to continued inadequate fuel supply. Common iron bars are 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel bars, 24*l.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.* 10*s.*; soft steel billets, 23*l.* 10*s.*; hard steel billets, 25*l.* 10*s.*; heavy sections of steel rails, 25*l.*; fish plates, 30*l.*; black sheets, 36*l.*; and corrugated galvanised sheets, 40*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The past week has not shown buyers as being any more desirous of entering the market yet awhile, and until things assume a more normal state no buying movement of any consequence is expected. The trade is somewhat unsettled owing to the labour unrest, but the postponement of the miners' strike for another week in the attempt to reach a satisfactory agreement and thereby bridge the differences prevailing in the coal industry, has given rise to the feeling that a strike will be averted even at the eleventh hour. Meantime all the steel works are fully employed and the plate mills are turning out a good tonnage, but even that does not seem to be sufficient to meet the immediate requirements, as large quantities are being consumed at the various shipyards and boiler shops. Sectional material is far from active and producers would welcome an increase in demand. Quite recently the rule was that orders for plates and angles combined were more acceptable to producers so that all plant could be kept going steady, and consequently angles were frequently ordered when not actually required. The result is that stocks of these are now held by consumers, and the demand is exceedingly poor. Makers of steel sheets are still active, but chiefly for the heavier gauges, as business in the lighter qualities has slackened off. Order books are well filled and a steady run is assured for some time yet, but competition from the south is being felt, owing to the fact that some of the fresh business on offer is being secured by English makers. Prices all round are without change. The export trade is still on a small scale, but is gradually improving, and if the present labour troubles were only past this branch of the steel industry would steadily develop.

Malleable Iron Trade.—The West of Scotland malleable iron makers are actively engaged with contracts on hand, and their output is being quickly disposed of, largely on home account. Export lots are also claiming the attention of producers, but the prices quoted are just a trifle too high for the foreign consumer. When the home demand eases off a bit it is then that the export prices may be shaded, but that is barely necessary meantime.

Scotch Pig-Iron Trade.—A strong tone prevails in the Scotch pig-iron trade, and the available supply still falls a good way below the actual requirements. Foundry iron and hematite are still very scarce, and there is a very active demand for each of these. The threat of a strike in the coal trade has had an unsettling effect, but with the outlook a little more hopeful a better feeling is noticeable. Export is quiet, but will improve to some extent when conditions are more settled. Prices are firm, but just a shade easier for shipment lots.

Wages in the Iron Trade Advanced.—Intimation has been made by Mr. John M. MacLeod, C.A., Glasgow, to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board, as follows: "In terms of the remit, I have examined the employers' books for July and August, 1920, and I certify the average net selling price brought out is 30*l.* 13*s.* 6·48*d.*" This means an increase in the wages of workmen of 15 per cent. on basis rates.

AN INTERESTING BUCYRUS JOB.—An interesting piece of work was recently accomplished by a Bucyrus electric drag line excavator at Englewood, Ohio, U.S.A. It was necessary for this excavator to cross the Stillwater River at a point where it is 250 ft. wide and 6 ft. deep. The crossing was accomplished by the excavator first building an embankment out into the stream. When this had extended some distance out the excavator moved on to it till it approached the end. It then cut into the embankment behind it and transferred this material to the front, and continued taking, so to speak, its inland with it, till a crossing 400 ft. in length had been accomplished. The embankment made was 30 ft. wide at the top and 60 ft. wide at the base, and was composed of gravel and small boulders. The job occupied four days of eight 10-hour shifts.

NOTICES OF MEETINGS.

THE INSTITUTION OF BRITISH FOUNDRYMEN (LANCASHIRE BRANCH).—Saturday, October 2, at 4 p.m., in the College of Technology, Manchester, Mr. W. H. Meadowcroft will deliver his presidential address.

THE SOCIETY OF ENGINEERS.—Monday, October 4, at 5.30 p.m., in the apartments of the Geological Society, Burlington House, W., a paper entitled "The Physical Properties of Clay," by Mr. Alfred S. E. Ackerman, B.Sc.(Eng.), A.C.G.I., M.Cons.E., A.M.I.C.E., M.R.S.I., will be introduced by the author, and then discussed. A paper by Lieutenant-Colonel H. R. Lordly, M.C.E., on "The Lateral and Vertical Pressure Effect of Piles in Clay," will be also read and discussed.

THE BRADFORD ENGINEERING SOCIETY.—Monday, October 4, at 7.30 p.m., Opening Lecture for session 1920–21 in the hall of the Bradford Technical College. Mr. C. K. Everitt, of Sheffield, on "Steel-Making Processes," with cinematograph illustrations.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, October 6, at 7.30 p.m., meeting of members in Wolverhampton district, at the Talbot Hotel, Wolverhampton, when Mr. Cyril Williams (winner of 1920 Junior T.T.) will read a paper on "The Racing Motor Cycle." Members of other branches who are interested in this subject will be welcome to attend this meeting.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The news of the suspension for a week of the miners' notices and the decision of the men's leaders to meet the coalowners and consider the proposed output datum line came too late last week to enable market operators to make arrangements for this week. Consequently the coal market is in a state of disorganisation. It is also fully recognised that up to the time of writing no real progress has been made toward a settlement of the miners' wages claim of 2*s.* per shift for adult workers, and that the datum line proposal bristles with difficulties. South Wales leaders have also to a certain extent damped the spirits of optimists by what practically amounts to a revolt against the principle of fixing wages according to output, and their resolution, sent to their members on the Miners' Federation Committee, protesting against their taking part in the London negotiations in respect to the datum line. In some quarters it is, however, believed that the South Wales leaders, when it comes to the point, will fall in with the national views. The position is, however, very uncertain. Meanwhile, though releases for export have been more readily granted this week, collieries are finding it very difficult to keep working regularly, despite the fact that the Ministry of Transport has supplied them with a considerable number of common-user wagons to make up for the large number of trucks sent inland. Shipping is also scarce, as a large number of vessels have been kept away and diverted from the district in view of the threatened strike. In fact, whereas a fortnight ago there were 332 ships in the local docks, to-day there are only 222. Spot shipping is in urgent request, and freight rates have advanced from 1*s.* to 5*s.* per ton, while buyers able to arrange spot delivery can secure coals of all grades at from 2*s.* 6*d.* to 10*s.* per ton less than a week ago. This, however, only applies to spot parcels which will enable collieries to secure a quick return of wagons which are so urgently needed at the pits. Best large coal is offering at anything from 105*s.* to 110*s.*, throughs 100*s.* and smalls 95*s.*, whereas a week ago it was impossible to secure large at less than 115*s.* Foreign coal exports in the past week at 244,000 tons, were 36,000 tons in excess of those for the preceding six days, and were distributed as follows: France, 95,000 tons; Italy, 50,000 tons; Spain, 9,000 tons; Portugal, 14,000 tons; British coaling stations, 58,000 tons; and other countries, 17,000 tons; while South America and Greece, for the third week in succession, did not receive any coal from South Wales. Coke and patent fuel are practically unobtainable, the output being almost wholly absorbed by contract commitments. For the small parcels of coke available prices ranged from 260*s.* to 280*s.*, and for patent fuel from 140*s.* to 150*s.*, which sellers have no difficulty in securing. There has been a sudden change in the pitwood position. Supplies were accumulated in August as a result of the dischargers' strike, and prices receded to such levels that importers "banked" stocks, and in view of the unsettled labour outlook arrivals since have been very limited. Consequently the glut has been turned into a shortage, while the unexpected suspension of the miners' strike notices caught some collieries short, with the result that buyers, who a week ago refused to pay 50*s.* for half-and-half (sixes and nine feets mixed), are now ready to pay as much as 65*s.*, which figure has been realised.

COLLOIDAL PHYSICS AND CHEMISTRY.—The forthcoming general discussion on "The Physics and Chemistry of Colloids and their Bearing on Industrial Questions," which is being arranged jointly by the Faraday Society and the Physical Society of London, has been fixed to take place on Monday, October 25, at the Institution of Mechanical Engineers, Storey's Gate, London, S.W. 1. The discussion will be presided over by Professor Sir W. H. Bragg, K.B.E., F.R.S., and it will be introduced by Professor Dr. Svedberg, of the University of Upsala, who will give a general survey of the subject before discussion is opened on its various branches. Non-members desirous of attending the discussion may obtain tickets of admission from Mr. F. S. Spiers, 10, Essex-street, London, W.C. 2.

1,750 K.V.A. SLOW-SPEED ALTERNATOR.

CONSTRUCTED BY MESSRS. THE GENERAL ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 440.)

FIG. 19. HALF STATOR ASSEMBLED.

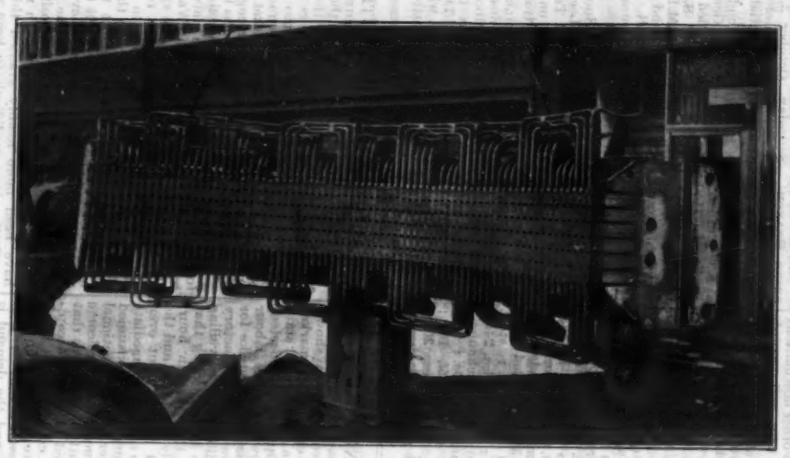


FIG. 20. A QUARTER SECTION OF STATOR.

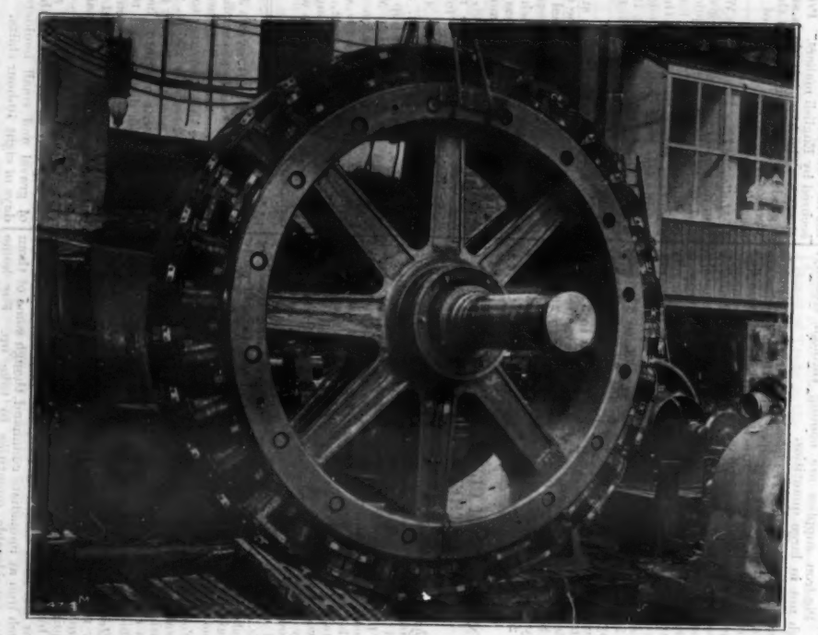


FIG. 21. THE ROTOR.

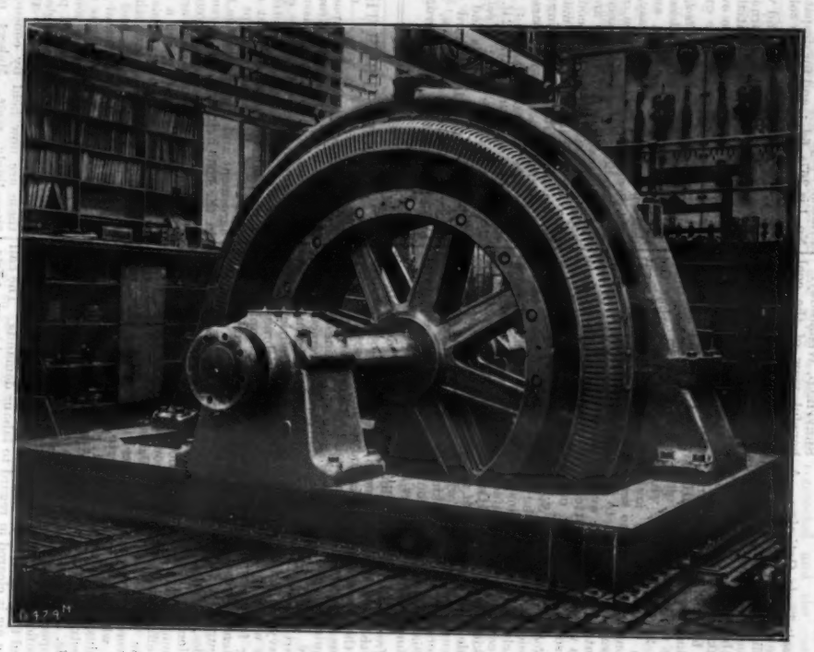
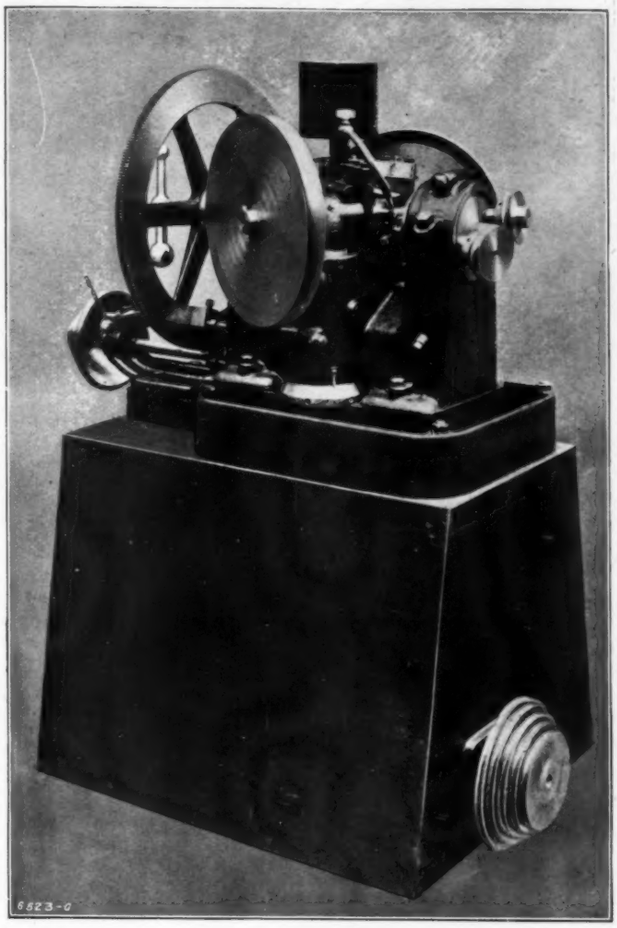


FIG. 22. GENERAL VIEW OF THE MACHINE.

THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Description, see Page* 430.)



Figs. 196 and 197. Twist Drill Grooving Machine; Messrs. John Holroyd and Co., Ltd.

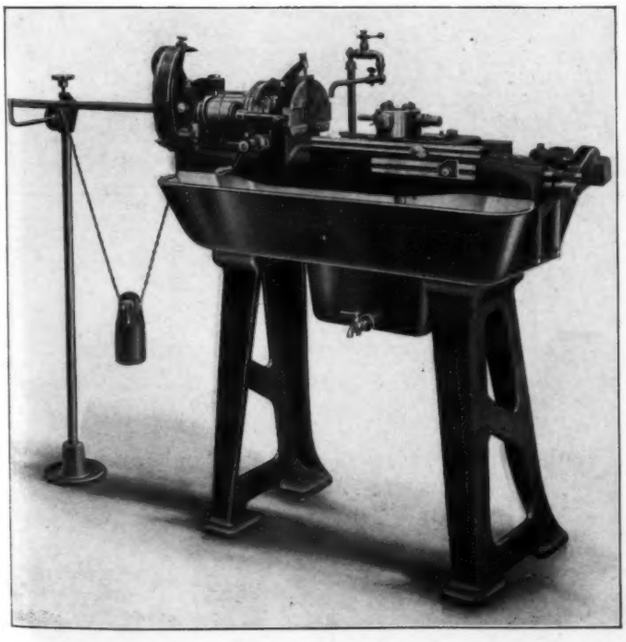


Fig. 198. Verity Patent Automatic Screw Machine; Messrs. Thos. White and Sons, Ltd., Paisley.

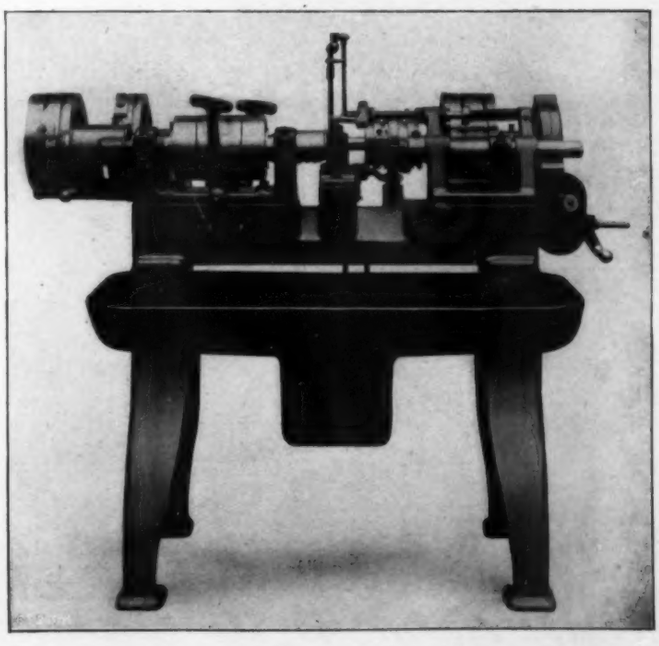


Fig. 199. Three-Operation Automatic Machine; Messrs. The Timbrell and Wright Machine Tool and Engineering Co., Ltd.

(*To face page* 430.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Description, see Page* 430.)

Fig. 200. Front View of Automatic Turning Machine; Messrs. Joseph Petermann.

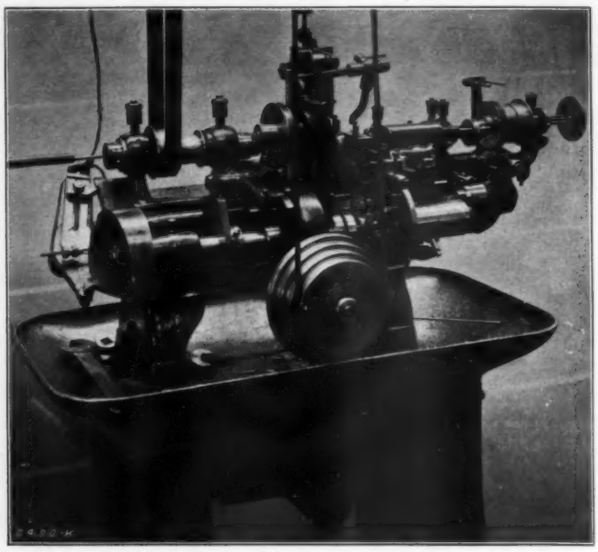


Fig. 201. Back View of Automatic Turning Machine; Messrs. Joseph Petermann.

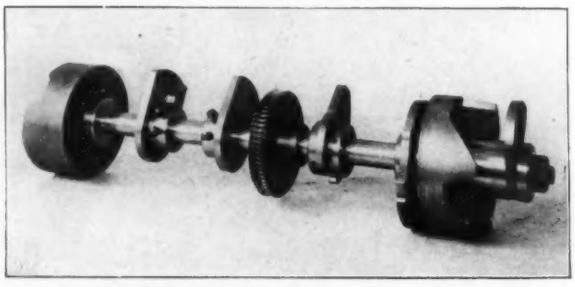


Fig. 202. Camshaft of Petermann Automatic.

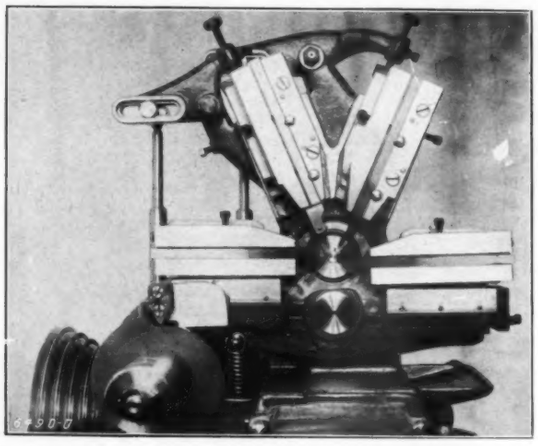


Fig. 203. Tool-Holders of Petermann Automatic.

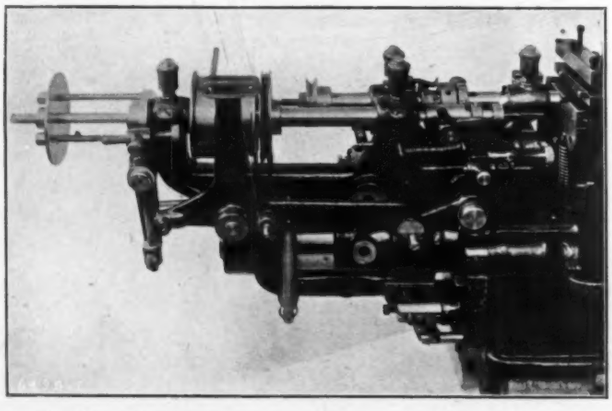


Fig. 204. Drilling and Tapping Attachment of Petermann Automatic.

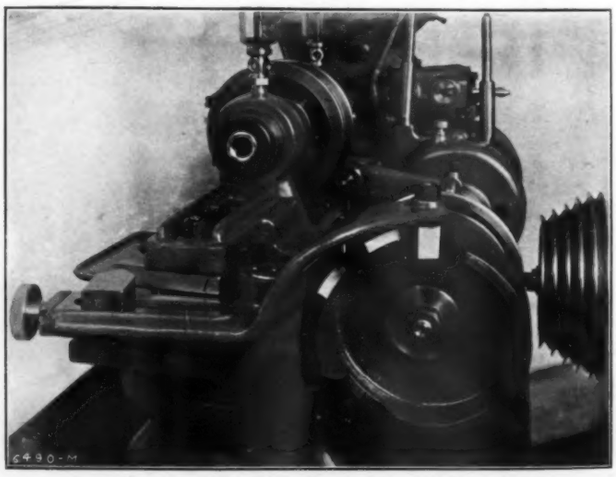


Fig. 205. Headstock Cam Control of Petermann Automatic.

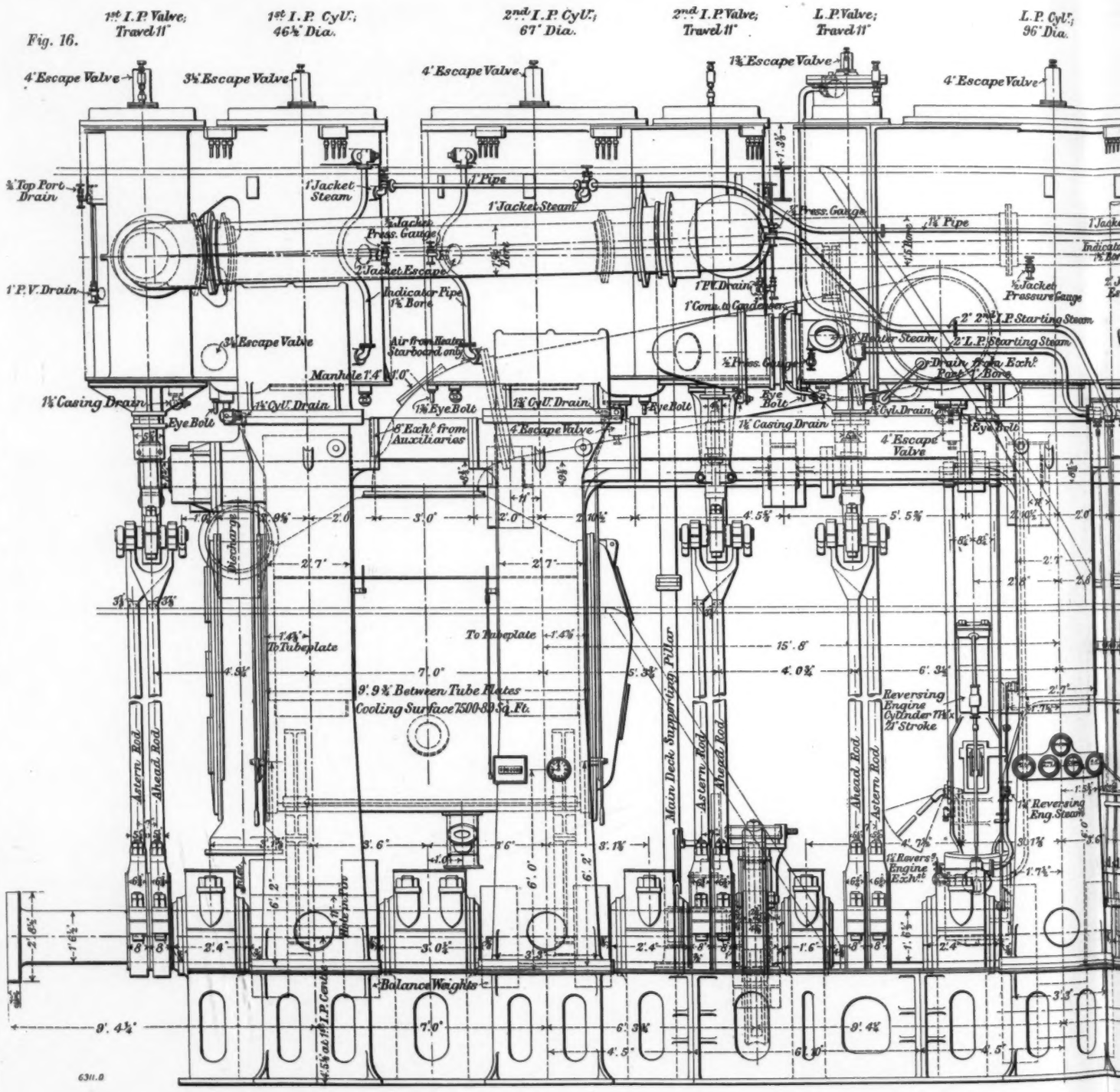
(*To face page* 431.)

7,500-H.P. QUADRUPLE-EXPANSION ENGINES F

CONSTRUCTED BY MESSRS. CAIRD AND CO., L

(For Description, see

Fig. 16.



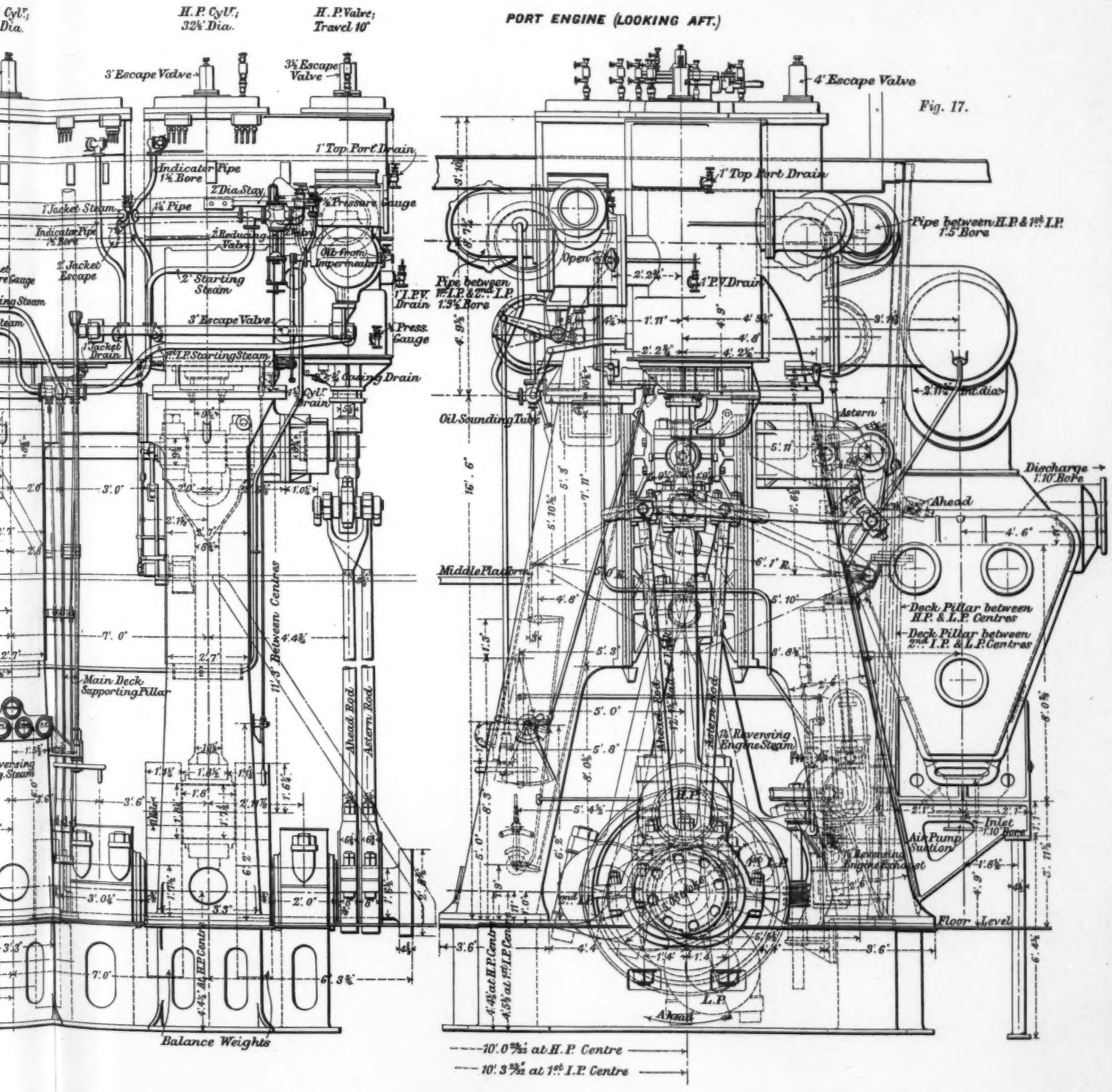
INES FOR THE P. AND O. LINER "NALDERA."

D AND CO., LIMITED, ENGINEERS, GREENOCK, N.B.

(For Description, see Page 453.)

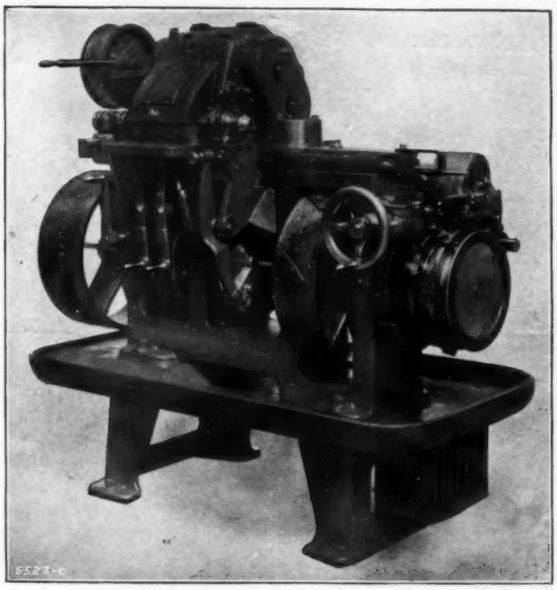
PORT ENGINE (LOOKING AFT.)

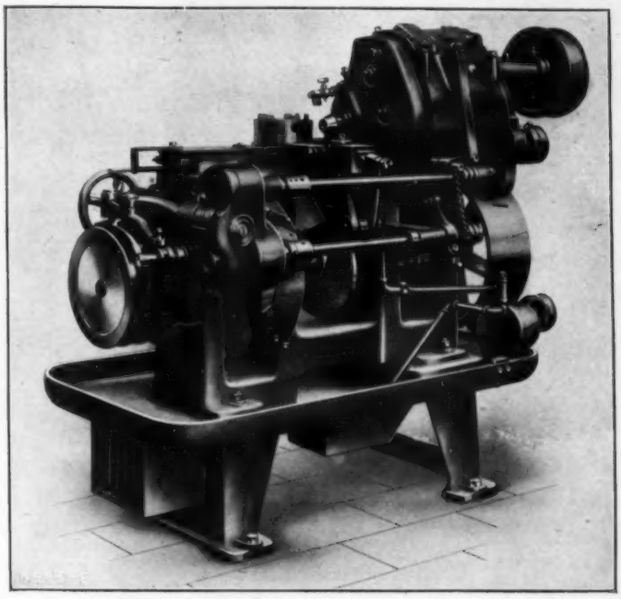
Fig. 17.



THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Description, see Page* 430.)





Figs. 206 and 207. Front and Back View of Automatic Screw Machine; Messrs. Thomas White & Sons, Ltd., Paisley.

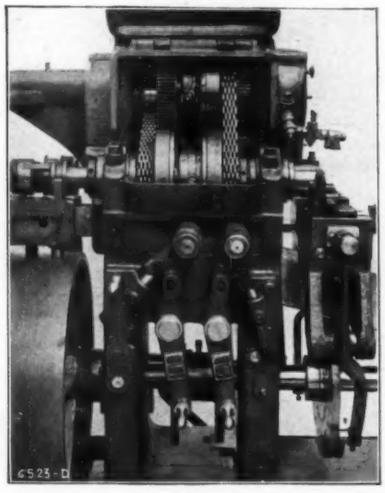


Fig. 208. Speed and Feed Control of White Automatic.

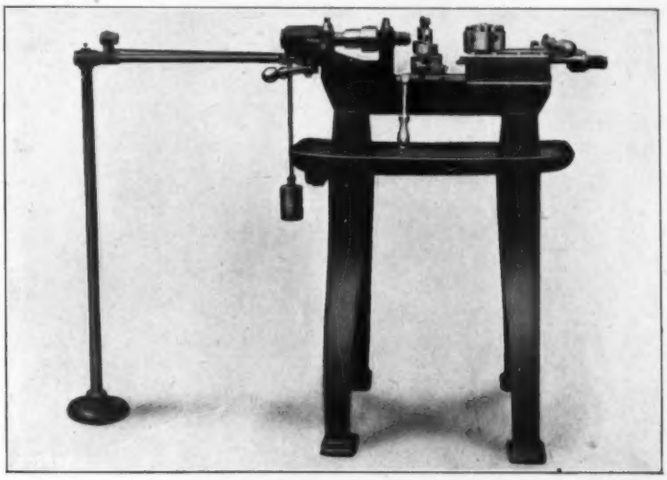


Fig. 209. $\frac{1}{16}$-In. Capstan Lathe; Messrs. The Timbrell and Wright Machine Tool and Engineering Co., Ltd.

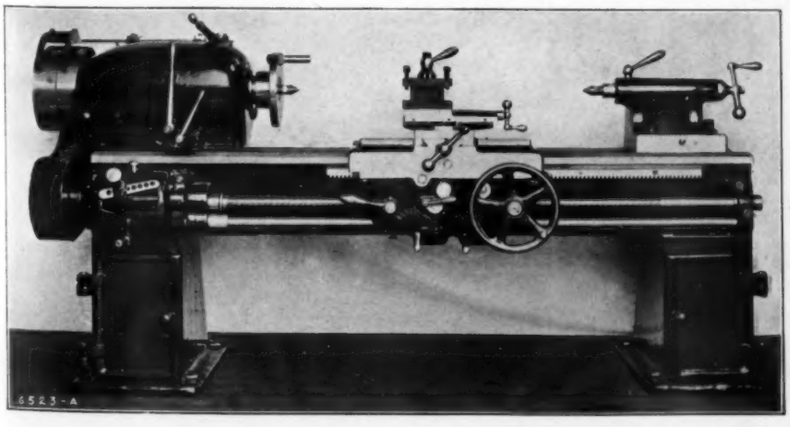


Fig. 210. 8½-In. All-Geared American Type Lathe; Messrs. The Colchester Lathe Company.

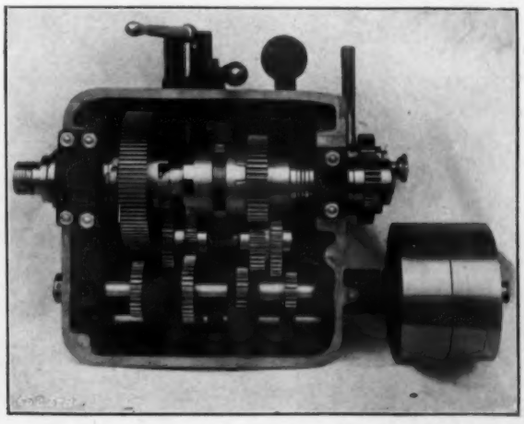


Fig. 211. Speed Gear Box of American Type Lathe; Messrs. The Colchester Lathe Company.

(*To face page* 432.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Description, see Page* 430.)

Fig. 217.

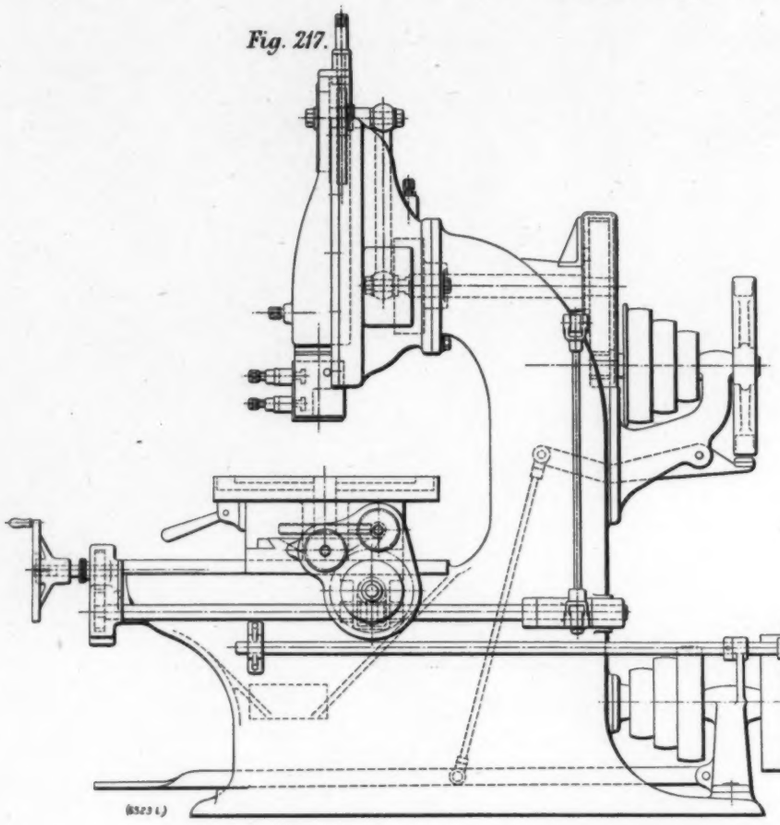
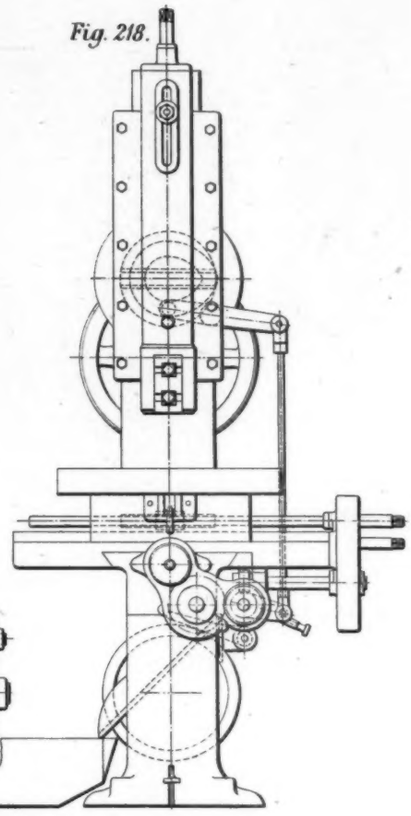


Fig. 218.



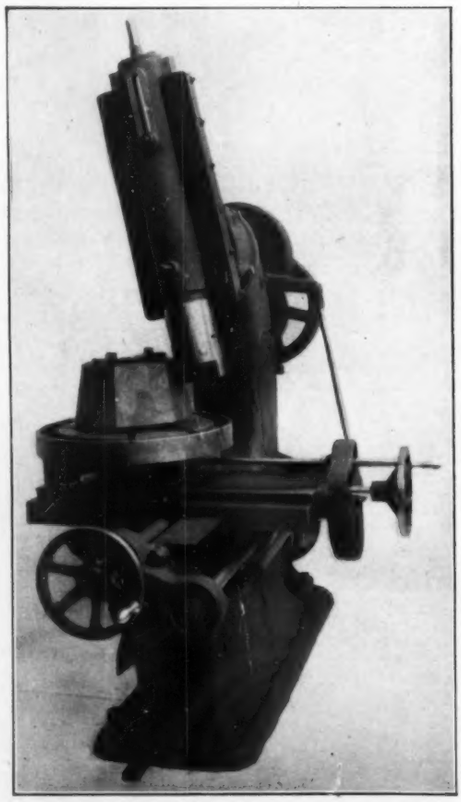


Fig. 219.

Figs. 217 to 219. 6½-In. Swivel-Head Slotter; Messrs. Harry F. Atkins, Ltd.

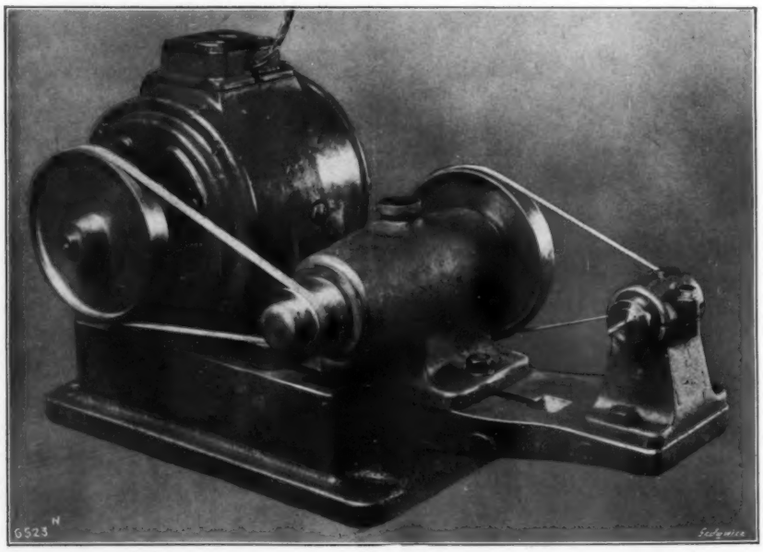
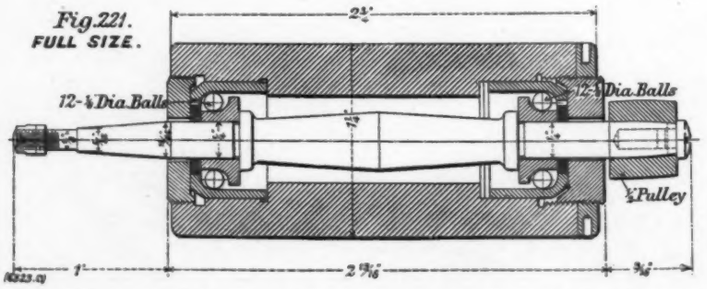


Fig. 220.

Fig. 221.
FULL SIZE.



Figs. 220 and 221. High-Speed Grinding Spindle; Messrs. A. A. Jones and Shipman, Ltd.

(*To face page* 433.)

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm Dawson and Sons, Manning Chambers.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co., Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Haywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long Street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements, J. S. Allan, 30, Church-street, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisments, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick ,, ,,	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick ,, ,,	£3	7	6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3883 and 8598 GERRARD.

CONTENTS.

	PAGE
Colloidal Chemistry and a "Colloid Mill"	429
The Machine Tool and Engineering Exhibition at Olympia (*Illus.*)	430
The British Association	437
The Tilling-Stevens Motor-Car Works	438
Industrial Notes	439
1750-K.V.A. Slow-Speed Alternator (*Illus.*)	440
Notes from South Yorkshire	443
Notes from Cleveland and the Northern Counties	443
Notes from the North	443
Notes from the South-West	443
Notices of Meetings	443
Scientific and Industrial Research	445
Safety in the Factory	446
Italian Labour	447
The Iron and Steel Institute	448
Notes	449
The Royal Agricultural Society's Trials of Agricultural Tractors and Ploughs	451
Twin-Screw Channel Steamer "Bruges" for the Great Eastern Railway Service (*Illus.*)	452
Labour Trouble: Its Immediate Cause and Remedy	452
Strikes	452
The P. and O. Liner "Naldera" (*Illus.*)	453
Cleaning Blast Furnace Gas (*Illus.*)	453
Electric Steels (*Illus.*)	456
Hydraulic-Fill Dams (*Illus.*)	457
The Effect of Heat Supplied to the Blast Furnace (*Illus.*)	459

With One Two-Page Plate of the 7,500-H.P. QUADRUPLE-EXPANSION ENGINES FOR THE P. AND O. LINER "NALDERA," and Four One-Page Plates of the MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 443.

ENGINEERING.

FRIDAY, OCTOBER 1, 1920.

SCIENTIFIC AND INDUSTRIAL RESEARCH.

WHEN the Committee of the Privy Council for Scientific and Industrial Research was established in 1915, the unusual step was taken of endowing it outright with a capital of one million sterling, so that the procedure of the expert advisers appointed should not be hampered by the necessity of justifying annually the expenditure proposed for each ensuing financial year. In the report just issued of the proceedings of this Committee,* it is stated that this policy has been amply justified by experience, as it is quite impossible to forecast satisfactorily in what direction funds may be needed. To a large extent this is controlled by trade conditions, since the general policy of the Committee is to support by grants-in-aid researches undertaken by associations formed by the industries directly concerned. In hard times, manufacturers' subscriptions will naturally tend to fall off, in which cases grants-in-aid will also be correspondingly reduced. Moreover, in other departments of the Committee's work, it would be impossible to justify to Parliament, year by year, investigations of the more fundamental type. The word research, in short, covers inquiries differing greatly in quality. Most so-called research is of the type which can be carried out by what Huxley called scientific hodmen, calling for nothing but care and intelligence on the part of the experimenter. In such cases a clear and definite programme can be drawn up and carried out in any well-equipped laboratory, since it is the apparatus and not the man which is of prime consequence. In investigations of fundamental importance, however, this is far from being the case. The really original thinker has at the outset no clearly-defined mark or aim. In fact, when he has worked long enough to be capable of clearly defining his problem, the latter is thereby half solved, but until this degree of success has been attained, his views, as the report says, "may appear hopeless and fantastic to the majority of intelligent people." In this connection, it may be noted that the original partners of Sir Charles Parsons broke with him because he refused to abandon his attempt to practicalise the steam turbine. Out of this they declared he would never make one copper penny of profit. There is not the slightest doubt that had Sir Charles been dependent on the support of any organisation of engineers, or on a State department, his compound steam turbine would have been stillborn.

In view of past experience of this kind, the Committee do not restrict their grants-in-aid to industrial research associations, but make also grants free of all conditions to men engaged in extending our scientific knowledge. These workers are appointed on the recommendation of university professors, and although in the nature of things only a few will prove men of genius and insight, the residue will constitute a corps of useful hodmen who are needed for routine work at our universities and for organised attacks on the more or less clearly conceived problems awaiting solution by our industries or by the various Departments of State. This latter class of scientific worker has always been plentiful in Germany and scanty here. In this connection the report contains some observations which do not seem entirely warranted by the actual facts of the case. It observes that "One of the obvious lessons of the war for peoples like our own, whose organisation is weak, was that rapid progress in the use of science with a view to defence or to increased production is not to be expected in any country which depends simply on the undirected genius of its people." Historically, we believe this statement to be untrue, and, in fact, the next paragraph of the report refers to the "extraordinary rapidity" with which we made scientific developments during the war. As instances, we may note the production of Seger cones and chemical glassware and porcelain within a few months of the cessation of the German supplies, and the rapidity with which we overtook the enemy in chemical warfare developments. Thus the "mustard gas" was made in Germany up till near the very end of the war by most imperfect and inefficient processes, whilst our own chemists worked out and practicalised most highly-efficient methods of manufacture within a few months. In all these cases the work was of a novel character, and was accordingly not hampered by pre-existing organisations, which tend to become staffed with "safe" men, at times of much erudition, but seldom endowed with insight. What we did suffer from was not the lack of a long established scientific organisation, which might well have proved as inert and unimaginative as the boards of Generals which condemned the tank and obstructed the adoption of the Stokes' mortar, but the want of chemical factories, so that after our chemists had solved their problems in the laboratory, we had then to build the works at which the new products were to be made, whilst in Germany the existing dye works, &c., stood ready to hand. It became necessary indeed to proceed with the manufacture of mustard gas before the factories were fully complete, and a considerable number of casualties resulted accordingly though, fortunately, only three proved fatal.

Of course, the necessity for getting the necessary scientific work done during the war denuded our universities of a large proportion of their trained men, and many of these, in view of the relative smallness of the salaries at present the rule for teachers and demonstrators, have not returned to their original employments. Moreover, the unprecedented crowd of science students which flocked to our universities at the end of the war, have made it necessary to take over for teaching purposes, many laboratories previously devoted to research, and as a consequence, many of the industrial research associations which had expected to work largely through local universities and colleges, have now found it necessary to provide laboratories of their own. The cost of these, at present prices, seriously depletes the funds which would have otherwise been available for financing the investigations desired.

Of these research associations there are now 18, having an income, provided by the trades concerned, aggregating some 40,000*l.*, and contributed by 2,300 members. The average subscription per firm is, it will be seen, not very considerable, but in many trades where very large firms exist, the latter prefer to run their own research departments instead of co-operating with their smaller competitors.

In the report for 1917–18, the Committee laid stress on the importance of including on the Councils of these research associations, direct representatives of labour. This would, undoubtedly, in every respect be a wise move as, naturally, science which aims at knowing how things work, is not favoured at Ruskin College, where the students merely acquire facility in drawing logical conclusions from plausible but unproven premises. It is most important for the future of this country, that labour (which, having by far the majority of votes, has for some years past had political control) should be given an opportunity of widening its culture, with the ultimate aim

* Report of the Committee of the *Privy Council for Scientific and Industrial Research for the Year* 1919—20. London: H. M. Stationery Office, 1920. [Price 1s. net.]

that the methods of Plato, as exemplified by the mediæval schoolmen and the modern politician, shall be replaced by those of science, where even the most taking theories are, in the first instance, only tentatively adopted, and then honestly and exhaustively tested by observation and experiment on a small scale, before being applied on a large one. Nothing is said in the present report as to whether the recommendation to include labour representatives on the local research councils has as yet been followed. The association with scientific workers would be bound to be beneficial, though it must be admitted that some quite distinguished scientific men seem to have minds divided up into water-tight compartments, and abandon scientific methods of thought so soon as they leave their laboratories. This phenomenon is a very peculiar one, and many examples could be given both amongst the living and the dead.

Whilst as a general policy the Committee follow the plan of helping only those trades which are prepared to help themselves, there are certain industrial problems of such general interest and importance to the public at large that it has been deemed both right and politic to finance them entirely out of the taxes. The fuel problem is eminently of this character, and about 41,000*l.* are to be expended during the coming year at the Greenwich research station. Here provision is made for the examination of all the more important qualities of coal raised in the United Kingdom. The arrangements are such that the coals can be gasified at any temperature between 500 deg. and 1,300 deg. Cent. During recent developments it appears that 8 to 9 millions of the 30 million therms in a ton of coal have been obtained in the gaseous form, together with 3½ millions in liquid products and 15 millions in the coke, the loss in the process being thus only about 10 per cent. Amongst the new plant now in erection at the Research Station is a setting of continuous vertical retorts, with which it is hoped to secure trustworthy data as to the economy of modern methods of gas manufacture.

The supply of motor fuel has long occasioned anxiety. The British demand for the ensuing year is estimated at 250 million gallons. Our benzol production is not nearly large enough to meet our wants, and an inquiry has accordingly been made into the possibilities of power alcohol. The conclusion reached is that this would be too costly a fuel if produced from domestic sources, but that a practically inexhaustible supply could be obtained from the tropics. Incidentally, it is noted that the use of gas for driving motor vehicles would be promoted by a general adoption of the practice of carbonising coal at 600 deg. Cent., in which case the gas produced has a calorific value twice that of ordinary town supplies, whilst the coke is admirably adapted for use in producers.

Another research of general importance is that conducted by the Food Investigation Board. This board has now discovered a method of freezing beef whilst preserving completely the physical and chemical properties of the fresh meat. Mutton has, of course, long been frozen, but beef should, as far as previous experience goes, be merely chilled or it will suffer seriously in quality. The new methods have proved successful in the laboratory, but have not yet been "practicalised" owing to the lack of adequate apparatus. This discovery should prove of very great importance in view of the fact that the Board have found that certain moulds to which the meat is liable will grow and produce spores at temperatures as low as 5 deg. Cent. below freezing-point. Further research on those most important matters will be facilitated by the completion of the experimental station equipped with cold storage chambers, &c., which is now being erected at Cambridge on a site provided by the University. The cost of maintaining this institution will be met by the Committee. Another matter of considerable interest is that it has been found that the life of fruit can be greatly prolonged by employing artificial atmospheres. Other noteworthy experiments are those which have resulted in the synthesis of glycerol, hitherto obtained solely from natural oils and fats.

The Building Research Board, established early in the year, is intended to set up rational standards for structural materials. The requirements of the ordinary building regulations are, as matters stand, largely absurd, no proper allowance being made for differences in the quality of materials, so that in general it has often paid best to use the worst qualities. Moreover, many building authorities seem to have entirely mistaken their function, which is to ensure reasonably safe and sound structures, and not to collect fees. Claims have repeatedly been made that railway companies and the like should be compelled to submit their plans to local surveyors, although the latter are in general less able men than the railway experts. The investigations already made by the Building Research Board show that certain substitutes for timber may be safely adopted, and that, with proper safeguards, thin walls may be used for the upper storeys of cottages built under national housing schemes. It has further been shown that the choice of aggregates for concrete has been far too restricted in the past.

Some very interesting work has been carried out for the British Museum, as Dr. Scott has devised methods by which the Assyrian tablets (of which Layard found such enormous numbers in Sennacherib's library), encrusted with deposits, have been cleared from these without injury, and he has also succeeded in removing incrustations from ancient coins of a copper-silver alloy, leaving the coin proper untouched. A highly interesting investigation is to be undertaken on others of these ancient alloys. These were cast 2,000 to 4,000 years ago, and it is expected that a systematic micrographic examination of their structure will yield valuable data as to their permanence or otherwise. Some alloys are certainly in only a meta-stable condition, and in that case their structure may be expected to change with lapse of time.

With respect to "aided" researches, it is disappointing to learn that some of the processes devised by the Tin and Tungsten Research Board have failed to fulfil their promise. Still more so is it to note that of the fifty firms who received formulas for the manufacture of hard porcelain from British materials, not one is developing commercially the manufacture of this variety.

The National Physical Laboratory is now under the direct control of the Committee. When originally established, the Treasury would promise nothing more than a grant of 4,000*l.* a year for four years. This was afterwards increased to 7,000*l.* per annum, an amount utterly insignificant as compared with the annual subvention of 100,000*l.* made at the same period by the United States Treasury to the Bureau of Standards. It is pleasing to learn that during the ensuing year the Teddington establishment will have an income of 203,000*l.* No doubt we cannot expect proportionate value, since the supply of men of first-rate ability is always limited, and such men are, moreover, likely to be attracted elsewhere once their reputation is established. An important new development at Teddington is that the Admiralty are to erect there a laboratory of their own, with a view to facilitating collaboration between their own technical staff and that of the National Physical Laboratory.

SAFETY IN THE FACTORY.

Every shopman has experience of shop accidents, and in some industries they are almost part of the day's work. Most employers and works managers certainly do their best to minimise the number of accidents, and with the assistance of our factory legislation and its administration they have been fairly successful as far as this country is concerned. This is not to say, however, that things might not be better. During the year 1919 the Home Office received notification of 1,384 fatal accidents, 40,058 accidents due to machinery and 84,582 non-machinery cases. These figures were rather below the average, and, of course, do not include accidents which are not reportable. Further, according to Mr. Gerald Bellhouse, the Deputy Chief Inspector of Factories, there is reason to believe that many accidents which are reportable are not reported. The returns under the Workmen's Compensation Act are probably more complete, and for 1913 the latest year for which totals are available, compensation was paid on 1,298 fatal accidents in factories and docks and 225,096 non-fatal accidents. These figures should not be misunderstood and can only properly be considered in relation to the number of work-hours or days over which they were spread and also in relation to corresponding figures for other countries. Allowing this, however, it requires no vivid imagination to realise that they represent much suffering and loss, which it is to everyone's interest to reduce if possible.

Industrial accidents are sometimes due to gross negligence on the part of the shop management in failing to provide proper safeguards in connection with dangerous machinery or processes. They are sometimes due to gross carelessness on the part of work people in failing to use safeguards properly or in deliberately taking risks. In general and on the average, however, they are due to slight oversight or ignorance on the part of one or the other. By ignorance on the part of the management we mean ignorance of possible but unlikely sources of trouble which have not been brought to notice by accidents actually occurring. By ignorance on the part of workpeople we mean failure to realise the danger inherent in all power machinery of any capacity, or in handling various moving parts, walking under suspended loads, slinging weights, &c. Many who had experience with unskilled or female labour suddenly imported into our machine shops during the war cannot fail to have noticed how workpeople of these classes would handle and take liberties with running machinery in a way that a skilled man would not normally dream of doing.

This reference to ignorance on the part of workpeople unused to machines must not be taken as a contention that skilled workmen and machine-minders do not also only too frequently act in a risky way either from forgetfulness or too complacent a self-confidence. The case of unskilled workers and their handling of machines is merely an extreme illustration of the cause of a considerable proportion of our industrial accidents, and it is in a reduction of this class that we must look for any considerable diminution in the total numbers. The accident due to gross carelessness on the part of the employer does not form any important proportion of the total, and is already fairly well looked after by our factory inspectors. The accident due to deliberate foolishness on the part of the employee is again not one of the most numerous, and it is doubtful if anything we can do will entirely eliminate it. The accidents due to oversight and ignorance may, however, be tackled, and judging by experience elsewhere may be considerably reduced in extent. The remedy would appear to lie in education.

As far as the average shopman is concerned education is, perhaps, not so much required in things he does not know as in things he does know. Every accident is unexpected when it happens, but in the majority of cases the actual occurrences are no surprise to either the management or the workpeople. No previously unknown factors, are as a rule, revealed. If the accident was to have been prevented, what was necessary was not education in something previously unknown, but education in something previously known—education not in reference to fact but in reference to the necessity for watchfulness and care. It is this education that it is the object of the British Industrial "Safety First" Association to help forward. This is not the only object of the Association as we understand the matter, but it appears to us the most important. Much can be done and much has been done by the fitting of various guards on to machines of all types and invention and the direction of attention to the subject will undoubtedly do more in the future, but at the stage we have now reached the greatest reduction of accidents must be looked for in this education to which we have referred.

To many people the British Industrial "Safety First" Association is an amiable fad which probably might be subsidised to the extent of a couple of guineas a year if it got noisy and influential enough, but which certainly cannot be allowed to interfere with the course of industry and output. This idea is perhaps understandable, and the expression "safety first" is certainly not a happy one. It would require no very subtle dialectics to demonstrate that from the point of view of actuality the expression is

absurd even when used in connection with the most intensive safety campaign in the most be-guarded factory in the country. The "Safety First" Association, however, is better than its name. It does stand for something practical and sensible, and it is to be hoped that the conference which it convened at the Olympia exhibition on Wednesday of last week may have done something towards bringing its aims to the notice of a wider circle.

One disadvantage of conferences of this kind is that they tend to attract the old worshipper and the neophyte rather than the stranger without the gates, but the device of holding this conference in conjunction with the machine-tool exhibition was a good one, and probably resulted in many machine-tool men becoming acquainted for the first time with the activities of the Association. We trust that such outsiders as attended the conference had the benefit of hearing the short speech which was delivered by Mr. H. E. Blain, who is the Honorary Secretary of the Association. Mr. Blain did not contribute to the formal series of papers which were read, but his remarks carried more enlightenment and conviction on the ways and objects of the Association than the more studied contributions. His speech was a model of terseness and clarity. We would also like to congratulate Mr. Blain on his delivery. He in common with Lord Leverhulme and Mr. Barnes had grasped the elementary fact that to interest an audience it is first necessary that they should be able to hear what one is saying. Many of the readers of the papers and the speakers in the discussion performed lamentably in this respect.

We have used the word "education" somewhat loosely in this article. The point we have been trying to make is that what is first necessary to reduce factory accidents is not the provision of more safeguards, nor yet the mere pointing out to workpeople of what constitutes danger. It is the continual and everyday insistence on the necessity for care and foresight throughout the factory. It is the education of everyone concerned to such a point that safety becomes a subject in which general interest is taken, and until the whole atmosphere of the shop is favourable to it. The idea of avoiding accidents should be instinctive with workpeople. It should not be something which they have to remember. One does not "remember" the alphabet. It is rubbed in too deep for that. A child of six does however, and it is to be feared that too many of our workpeople avoid accidents by remembering them in the way a child remembers the alphabet and not in the instinctive way an adult deals with it.

The actual means by which the "Safety First" Association propose that this atmosphere of interest in safety should be introduced into our factories were well explained in the paper read by Mr. Gerald Bellhouse. The idea is that, particularly in large factories, an officer should be specially appointed to look after the matter. He should be a sort of local factory inspector, and all guarding of machines and processes should come under his supervision. This inspector should, of course, attempt to interest the foreman and the workers in the movement, and to assist in this a Safety Committee is proposed, representing the management and workers, to meet at regular and reasonably frequent intervals. This committee would inquire into accidents, and consider proposed improvements in methods of safety, particularly in conjunction with a suggestion scheme open to contribution from all workers. A further important recommendation is in connection with the use of bulletin boards on which would be posted a regular succession of posters, illustrated or otherwise, pointing out various dangerous practices to be avoided and inculcating generally the undesirability of carelessness. These posters would be the kind of thing with which many of our readers will be familiar in connection with the London underground railway and motor omnibuses.

It will be seen that there are two ideas underlying these recommendations. In the first place it is proposed that the study of safety in any factory shall be formalised and made into someone's definite job. In the second place what is in effect an educational campaign is proposed. The posters would form an important part of this, and there is no doubt but that a constantly-changing series of striking matter would in time influence the workers sub-consciously so that they would gradually and in greater or less degree come to practice what was preached. These various proposals could not, of course, be carried out without expense, but there is no reason to suppose that it would be unduly heavy. The posters would, we imagine, be supplied to subscribers by the "Safety First" Association, and the special safety officer should certainly justify his keep in the saving of expense resulting from reduction in accidents, quite apart from the humanitarian point of view.

"Safety First" movements generally on the lines we have indicated have been introduced at Port Sunlight, at Messrs. Edgar Allen's works, by the British Thomson-Houston Company, Thomas Firth and Son and others, in all cases with very considerable success. At Port Sunlight, where luminous signs, special warning devices, &c., have been installed to a very considerable extent, the system had resulted in a reduction of the number of accidents by 50 per cent. by the end of 1917, the following year showed a further reduction of 12 per cent., and by the end of 1919 there was a still further fall of 5 per cent. The results for the first half of this year are still better and show a reduction of 20 per cent. as compared with the corresponding period of last year. At Messrs. Thomas Firth's works the suggestion scheme has been a great success. The proposals put forward have mostly been not of a novel nature, but have been very useful, and as Mr. H. S. Burn, who read a paper on the subject, pointed out, they mostly concerned work which ought to have been done in any case. In some firms the regulation has been made that all accidents, however trivial, must be reported to the ambulance room. This is with the idea of preventing cuts and abrasions resulting in septicæmia owing to lack of attention. A speaker from one firm stated that employees received a special maintenance grant over and above any ordinary out of work payment if they were absent owing to injury received at work. If, however, they were absent owing to an injury which had not been reported at the ambulance room the gratuity was not paid. This greatly assisted in obtaining observance of the regulation.

ITALIAN LABOUR.

No apology is needed at the present time to excuse the amount of space which is being given in technical journals to the labour situation the world over. It should most strongly be emphasised that the very serious unrest prevailing in many trades and in most of the industrial countries of the world is giving rise to that unsettled state that reflects adversely alike on commercial as on technical progress. Is it fully realised how largely our leading engineers and industrialists are devoting their time and their attention to the solving of one difficulty after another connected with labour affairs rather than to the development of industry—commercially and technically? No estimate is even possible of the loss so occasioned.

In this country the trend of affairs recently in the north of Italy has been given very grave attention. Socialistic agitation in Europe since the war has shown a strong tendency to convert economical disputes into political questions, and in some cases the issue has been pushed so far as revolution. Unfortunately, this tendency has been strongly marked in Italy due in measure to the workers, although earning much higher wages than previously, suffering greater hardships than similar classes elsewhere. Food cards, limitation of the bread supplies in many districts, difficulties in obtaining the necessities of life, rice, flour, lard, oil, butter and, above all, fuel in winter, should be mentioned. Many other commodities, although fairly abundant in other countries, are still very scarce in Italy, while the workers can only at present look forward to spending their fifth winter without adequate supplies of coal, the price being more than 700 lire (or at the present rate of exchange 8*l.* to 10*l.* sterling) per ton.

It can hardly be wondered at then that this ground is fertile and prepared for the sowing of the seeds of discontent with the consequent strike actions. Coal may be said largely to be the crux of the situation in Italy as it is elsewhere, and we wonder whether reasonable attention has been given by our great trades unions to the effect of a coal strike not only on the people of this country, but in others, in spite of the loud protestations, which are never absent from the many Labour congresses, of the brotherhood of labour. Ignorance due to insular position, explains much, but a wider power of labour can only be tolerated when based upon knowledge of fundamental facts, existing conditions and a good knowledge of affairs. We look almost in vain for signs of any material improvement in labour's outlook in these directions.

A great relief was felt by all last week at the happy turn which negotiations at home then took, culminating in the postponement of the coal strike notices for a week pending discussion between our miners and coal owners regarding the fixing of a datum line of coal output above which a bonus for increased production will serve to give to the miners the greater wages for which they ask. With an increased output little objection would be raised to this course. This rise in wages at least would be guaranteed not to have the effect so often observed of higher wages incurring reduced output. In no country would greater satisfaction be felt than in Italy at this change in prospects in regard to coal, and although, at the time of our writing, a serious hitch in the negotiations is threatened, it is earnestly to be hoped that the ultimate results may be satisfactory to all concerned.

To turn to the expression of Italian discontent; some weeks ago, the workers in the leading factories—metallurgical and engineering—in the North of Italy put forward a demand for a 50 per cent. increase in wages. This led to a strained situation and a lock-out of the men by the employers was threatened. To prevent this action being taken the workers took over the factories and organised themselves so that at no time were the works left unoccupied by the employees. As a class, we are pleased to testify, these are neither lazy nor unintelligent, and it was realised that for the carrying on of the work the technical staff and the works direction must be retained. To this end generally the management were prohibited at first from leaving the works, and the work was carried on as before without serious disturbance. It was quickly realised, however, that so complicated is the fabric of organisation necessary to insure supplies of raw material and to make financial arrangements, that the position was economically impossible. The workers had to learn that raw material does not find its way automatically into the factory, nor the finished product to the market. The behaviour of the men has been good, yet the work gradually came more or less to a standstill. The trades unions issued edicts and their officials enforced orders which, had they come from other than their own elected representatives, would have been regarded by the men as autocratic in the extreme. Only one example need be given. One of the articles of the trades unions' edicts states that "whosoever comes late or leaves off work before the appointed time shall lose his pay for that whole day's work."

The one outstanding circumstance of note which either might have terminated the present "strike"—if so it may be named—or caused the movement to take a more violently revolutionary turn is, that no money was forthcoming for wages on pay day, the banks, of course, refusing to disburse to this end. The latest news from Italy shows that a temporary settlement has been reached. Councils similar to those of the Whitley scheme in this country are to be imposed by law. Information is yet lacking as to the definite scope of these bodies composed of equal numbers of workers and employers, but so far as reports go they point to much wider powers than has yet obtained at home in similar cases. It is to be hoped that the Italian workers with their capacity for work, and their relatively high degree of skill and intelligence, will have learned a lesson from this tentative experiment in sovietism of the last few weeks, and that in due course wiser counsels will prevail, and these combined bodies will settle down on an equable basis for the best results. The sharing of the profits of industry

can only be justified if the losses are also shared. If a full measure of the profits are to be allocated to the workers, they must also take the same measure of the risks. These councils at least will serve one important end, and that is, to prove conclusively to the workers that the enormous profits which they believe are being made by the employers and which they claim to share, exist only in their imagination. We trust that the more extreme element in our own labour movement will study and benefit from the experience of the recent Italian situation, and to this end it is hoped that full and complete reports will in due course be published here of the basis of the final settlement when reached.

THE IRON AND STEEL INSTITUTE.

(*Concluded from page* 414.)

The members reassembled in the building of the South Wales Institute of Engineers, Cardiff, on Wednesday morning, September 22, for the further reading and discussion of papers.

Rough Cleaning of Blast-Furnace Gas at Skinningrove by the Lodge Electrostatic Process.

The first paper taken was the one bearing the above title, contributed by Mr. A. Hutchinson and Mr. E. Bury. It was read in abstract by the former. We reproduce it on page 453 of the present issue.

The discussion was opened by Professor H. Louis, who stated it would have been interesting to receive at the same time an account of the Cottrell process in use at Moss Bay where it seemed to be doing admirable work, and to compare at the meeting the two processes side by side. He would like to know in what particulars the Lodge process differed from the Cottrell process; it was, he thought, difficult to discriminate between the two, and it would have been satisfactory to have the points of difference entered into on that occasion. The authors had said that in their plant the results they had achieved had been attained with a total fuel consumption corresponding with 50 kilowatts only; he asked whether that meant the total power consumption for electric current and for passing the gas through the plant, also to what quantity of gas that applied. He congratulated the authors for the courage they had shown in putting forward their paper so short a time after the process had started running at their works, and this certainly augured well for the process.

Mr. A. K. Reese thought a disadvantage of the process dealt with by the authors was the vital necessity of constantly maintaining a regular flow of gas through the apparatus, so as to prevent some gas passing through uncleaned. If this were a necessity, then the system must require a very large amount of attention, and there might possibly ensue a very irregular result from the plant. An efficient plant in this connection, he thought, must be a more or less automatic plant, and he asked whether means had been considered to render the plant in question automatic in its action. Wet systems and other systems were automatic, except for the keeping of the mechanical parts sufficiently lubricated.

Mr. H. M. Ridge appreciated the practical value of the authors' contribution; it had been given within a very short time after the starting of the installation, and he thought the members should not be too critical at this comparatively early date. He would like to know, however, whether the authors had found it possible to reduce the dust content in the cleaned gas, since this sometimes became necessary—or, in other words, whether it was possible, as regards dust content, to get still better results. In the matter of dust removal, the capital outlay for the plant and also the working costs came in, and were important items; if the authors could add information as to these points, this information would be found of great interest. The capital cost was high in the case of the Halberg-Beth system. It meant a heavy outlay for what might be termed an accessory plant. He also asked what was the difference in the pressure of the gas in the mains and at the point where it entered the cleaner. One of the advantages claimed by the authors as being due to using cleaned blast-furnace gas, *i.e.*, a saving in gaseous fuel consumed arising from the greater thermal efficiency of the gas, might, he thought, be amplified; the flame effect was greater, and one could utilise smaller gas passages in the stoves. In former appliances, the gas passages were too great to utilise the thermal efficiency in the gas. This also applied to the utilisation of the gas under steam boilers.

Mr. J. S. Hollings found that the authors' figures of reduction in temperature of the gas seemed to be satisfactory; there was a waste in that respect in the wet process. Their figure of the dust content in the rough cleaned gas at Continental plants should, he thought, read 0·1, and not 1 gramme per cubic metre in the water-washed gas. The authors had given the figures now obtained at Skinningrove as being 0·8 gramme to 1·1 gramme per cubic metre in the cleaned gas, a proportion which seemed to be a high one; in his (the speaker's) plant, with large static gas catchers, he obtained 1·25 gramme to 1·4 gramme per cubic metre, and found it necessary to clean the stoves about every nine months, the specific gravity of the dust at his (the speaker's) works having, perhaps, some influence on the figure.

Dr. Rosenhain found the paper interesting also, in that it showed a useful development on a large scale of a scientific problem which was simply considered as such in former years; it pointed to the fact that the abstruse questions of a former generation could well become of practical importance in the time of the generation following.

Mr. F. W. Habord said he would like to know the cost of the plant if this could be given. In a process used in the United States, the gas was filtered through steel wool, and it was claimed that, the proportion of dust was thereby reduced to 0·5 gramme per cubic metre; it seemed to work satisfactorily. One was to be put down in this country, but it was not yet known how it would answer under our conditions. The question, however, resolved itself largely in one of capital cost.

Mr. T. C. Wild understood that potash was encountered in the finer particles of dust, and asked whether some dust rich in potash did not pass out with some of the gas at the chimney stack.

Dr. Stead said that the electrostatic precipitation of dust was referred to in some old text books, and Professor Lodge, as was well known, had suggested that the method might be applied to the dispersion of fogs, a suggestion which would not answer. He (Dr. Stead) had proposed that it might find an application in removing the dust from blast-furnace gas.

In the course of his reply to the discussion, Mr. Hutchinson said the Cottrell process was essentially, he believed, the same as the one put down at Skinningrove, but there were at the same time many details which differentiated the two. In the electrolytic process at Skinningrove the current was unidirectional. Lord Moulton had called at the works and had expressed himself greatly interested with the preparatory plant he had seen there. He told the speaker that probably difficulty would be experienced with the platinum points, but in the working no difficulty occurred, the points were maintained in an atmosphere of hydrogen, and there were no short circuits between the platinum points and the mercury cups. He (the speaker) thought there was difficulty in the matter of the plant at Moss Bay in regard to the distribution of the gas in the different chambers. At Skinningrove they had adopted sixteen chambers, and this constituted, perhaps, an essential difference between the Cottrell process and the one selected by the authors. In the main they were, perhaps, identical, but they differed in what he would term the chemical engineering devices on which the success of the whole process depended. At Skinningrove they ensured that the whole gas came in contact with the electrical apparatus, and they dealt with the total blast-furnace gas of four blast furnaces making from 3,000 tons to 4,000 tons of pig-iron per week. Regulation of the gas flow was effected by valves on each side of the cleaning chamber, and it could easily be ascertained, when the gas came from the chamber, if it was sufficiently well cleaned. The staff consisted of two electricians and two cleaners, whilst the gas was attended to by the ordinary gas man of the blast-furnace plant. The difference in pressure between the ingoing gas and the outgoing clean gas was between $\frac{1}{4}$ in. and $\frac{1}{2}$ in. of water. As to the effect on the stoves, it was a little too early to speak; with regard to the saving by the utilising of the sensible heat and of clean versus dirty gas, the authors had to wait until they relined the stoves, when they would probably lay the bricks in the stoves closer together than they were now. The process was at its present stage intended to clean the gas sufficiently not for its utilisation in gas engines, but only in the stoves and under boilers. The cleaning beyond a certain given proportion of dust resolved itself simply into a question of capital expenditure. It was quite true that some potash still remained in the fine fumes which escaped through the chimney stack, but they were doing very well at Skinningrove in the extraction of potash by the method. It was difficult to give figures of capital cost, but he could say that the electrostatic part of the plant actually cost £30,000. It was hardly fair to give a total figure to cover the whole plant, since the tubing and other elements would vary from one instance to another. He might conclude by saying that the plant was a pretty one from a scientific point of view; it might be likened to a lecture table apparatus rather than to an industrial process, but it was fulfilling the functions of both.

Variations in the Heat Supplied to the Blast Furnace and their Effect on the Fuel Consumption.

The second paper taken at the meeting of September 22 was the one the title of which we give above, by Mr. W. W. Hollings. It was read in abstract by the author; we reproduce it on page 459 of the present issue.

The discussion was opened by Mr. A. K. Reese, who said he supposed his works were the only ones in this country to use dry blast, and it was, therefore, incumbent upon him to defend that method. The author's paper resolved itself into a strong attack on dry blast; he (the speaker) had no theoretical figures to put forward in regard to the advantages of dry blast, but the results which it actually gave might, he felt sure, vary the author's conclusions. Theory was undoubtedly of great value in many cases, but practical results were of greater value still, and in blast furnace practice it might be said that theory seldom fitted in. For example, the theoretical burden that fuel should carry was not the same as the burden which the fuel actually did carry. In a general sense, the author's paper was an interesting one, but it did not help the manufacturer. He (the speaker) had been working with dry blast for the past ten years; he had carried out tests, using the dry blast plant in the early days of the installation, he had watched the results closely, notably the fuel consumption, and had found the results very conclusive indeed. He had not made any comparative experiments since, as he felt there was no necessity at all for doing so; he certainly saw no reason at all for going back to natural air.

Blast-furnace practice, he continued, involved many variables which affected the working; it was difficult when arriving at different results for one period compared with those of another period, to say that the difference was due to one stated cause. The burden carried by the fuel was an excellent guide, perhaps a better guide than others. Previous to the use of dry blast at Cardiff, the maximum burden of ore was 18 cwt. per barrow of fuel: after the dry blast plant was put in, and in normal times, that is to say before the war broke out, the maximum burden became 20 cwt. per barrow of fuel, using the same coke, the same Spanish ores, and working under the same general conditions. One barrow of coke weighs about 9·5 cwt. That was one explanation that could be given to point out the saving due to dry blast. Dry blast also helped in other ways. Previous to the use of dry blast, he (the speaker) was limited in regard to the blast the furnace would carry, and irregularities occurred; now he could run the blast at as high a temperature as he could get. He worked at 1,400 degrees, and also 1,500 deg. if he could get that temperature in the blast, and there occurred no hanging up and

no sticking in the furnace such as were experienced when using natural air. One important point gained by the use of dry blast was that when the furnace "went off colour," the grade of iron obtained falling to, say, grade No. 4, the quality of that iron for steel making did not deteriorate to the extent which it did when using natural air. Using natural air only, the sulphur content would go up following the variations in the working. The concentration of the air gave a higher percentage of oxygen per cubic foot as was well known, and it was all to the good. The higher heats and better working he (the speaker) obtained owing to dry blast were the result of uniformity and reduction of moisture in the blast. The material as it descended the furnace first became pasty, and it was at that region that scaffolding might take place. The more uniformity there was in all the conditions, the more economical was the running of the furnace; it was desirable to have not only uniformity in the ore as regards quality and size, but also uniformity in the blast, since blast which was always varying in moisture led to variations in the efficiency of that blast. If one had a constantly varying melting zone one had also a constantly varying pasty zone, this leading to irregularities in the working of the furnace. Dry blast had the effect of maintaining the pasty zone always at the same level in the furnace, and of removing the cause for sticking, there being a regular descent in the furnace. Dry blast, he repeated, allowed a higher temperature to be carried in the blast. It might be that the conditions ruling at the author's blast furnaces at Brymbo did not make for the use of dry blast; at all events, his (the speaker's) actual experience at Cardiff disposed of the author's broad statement as to dry blast.

Professor Louis disagreed with the last speaker's premises as to theory not being applicable to blast furnace practice; if theory and practice did not agree it was because the facts were not correctly observed, or the theory was badly applied. The author's paper was difficult to follow in some instances; he used the same letter A for different items in his formulae. He apparently based his theory on the hypothesis that all the carbon used in the reduction of the ore was oxidised to CO_2, whilst it was well known that a part was oxidised only to CO. If that were a fundamental point in his theory, then the paper fell to pieces. He did not agree with the author's conclusion that the process of blowing with oxygen-enriched air was not likely to result in any appreciable saving for a small percentage increase in the oxygen. The oxygen-enriched air would burn the carbon more completely to CO_2 in the tuyere zone and would make for economy. The question of oxygen-enriched air was one which required to be tried thoroughly. It was always the endeavour to purify all the material which was put into the furnace, and it was not a mistake to try and remove the impurity from the air.

Mr. F. W. Harbord also thought Mr. Reese's attitude in regard to theory was not exactly a correct one to take. It was necessary to determine theoretical conditions and to endeavour to aim at them. On the other hand, he thought that the author had not fully established his position; some facts on which he based his theory could not be regarded as correct. He (the speaker) agreed with Professor Louis as to the advantage of oxygen-enriched air.

Here Mr. A. K. Reese interposed that he was not opposed to all theory, although he thought it was impossible to prove by mathematical calculation what went on in the blast furnace.

Mr. W. J. Foster thought that the dry blast process as introduced appeared to be rather an expensive luxury, but the advantage of drying the air would be characterised by a corresponding decrease in the cost of upkeep of the furnace. It was necessary to get the blast furnace to a high temperature to decompose all moisture into its molecules, and the chief zone in the furnace was the reducing zone, whereas formerly the top of the furnace was considered the most important one.

Mr. W. Moore believed that Mr. Reese's dry blast plant was not the only one in this country. In his (the speaker's) experience he had found it a definite advantage to go in for dry air.

Mr. J. S. Hollings found that the speakers who had expressed opinions adverse to the author's findings had not given their own figures, and it was difficult to apply the theory in the paper to their results. He had made, in conjunction with the author, a series of three tests each of six months' duration, and the net results arrived at were those quoted in the paper. From the financial point of view, the results quoted in the paper were substantiated by general experience. There were two dry blast plants in the States, one in Germany, and, he believed, one in France, but he did not think they were successful. In this country as many had been put out of action as were in actual operation. He hoped Mr. Reese would read a paper giving the full results with his dry blast installation.

Mr. C. H. Ridsdale referred the members to the paper on blast furnaces which he read at the last May meeting, and to his reply to the discussion thereon, and stated that the hearth, as was well known, was the most sensitive part of the furnace, and if dry blast increased the heat in the hearth, there was obtained a corresponding saving.

Mr. C. S. Gill said he had no practical experience with the use of dry blast; uniformity in the blast seemed to be its strongest point. He thought that Mr. Reese went perhaps too far when he said that a low percentage of sulphur in his pig-iron was due to the use of dry blast. With his (the speaker's) furnace No. 8 he noticed the same point in regard to sulphur, although he did not use dry blast. The iron was low in grade, but it also showed a low sulphur content. It was necessary, therefore, to look further than dry blast to account for the occurrence. In regard to the economical point of view, the coke consumption in his (the speaker's) particular furnace was very good, about 18·5 cwt. per ton of pig-iron made. The temperature in the stoves was also fairly good, being from 1,400 deg. to just over 1,500 deg. Fahr. Consett, where the furnaces were located, was about 900 ft. above sea level, and the moisture in the air at Consett was, perhaps, lower than that in the air at Cardiff. The coke at Consett was variable, but they tried to keep the good coke for the furnace No. 8 in question; the ash was never less than 10 per cent., and never higher than 12 per cent. The ore they used was Spanish ore from various Spanish mines, mixed with a small proportion of purple ore briquettes.

In the course of his reply, Mr. W. W. Hollings said he thought the remarks made by Mr. J. S. Hollings partly covered the points raised. The statement in the paper that the oxygen of the air burned the carbon to CO_2 was based on one example, and as Gayley's trials were on the same furnace and with the same ore, he (the speaker) had taken the point and applied the theory mathematically. In regard to the oxygen-enriched air, he thought Professor Louis was perhaps under a slight misunderstanding, for he (the speaker) did not say it would be disadvantageous if there were a fairly large increase of oxygen; a small increase only would not result in sufficient advantage to pay for the plant for providing that small increase.

Electric Steels.

The last paper taken was one on "Electric Steels," by Mr. C. G. Carlisle. We reproduce it in abstract on page 456 of the present issue.

The discussion was opened by Mr. E. H. Saniter, who stated that many papers had already been read before the Institute dealing with the electric furnace, but the paper by Mr. Carlisle was the first one contributed by a manufacturer of steel in the electric furnace, and deserved, therefore, a hearty welcome; it was hoped that other makers would come forward with the object of filling up the gaps which still existed in that branch of steel metallurgy. The author claimed that steel of great purity, from the point of view of sulphur and phosphorus, could be obtained in the electric furnace; that was so, but almost the same results from that point of view could be arrived at in the basic open-hearth furnace. In one of the author's statements it was said that part of the sulphur present in the slags existed as SO_3; he (the speaker) did not think that such could be the case. With regard to Geilenkirchen's assumptions as to the removal of sulphur in the electric furnace, a theory which was confirmed in the main by the author's work, he (the speaker) did not fully agree, as the same results could be obtained in the open-hearth basic process in the presence of oxide of iron. He had tried to desulphurise steel in the ladle with carbide of calcium, but had not arrived at a satisfactory result. A fine steel was made in the electric furnace, but it required patience and care to make it. The author had said that he could make a solid steel without using killing agents for the slag, and he (the speaker) asked why he found it necessary to add 0·1 to 0·2 of silicon if he could make a solid steel without it.

Dr. A. McCance said that there existed in some quarters prejudice against electric steel; the subject was one that should be looked into impartially as it affected an important section of the steel industry. The question resolved itself largely into considering who made the steel. An electrical engineer could not make the steel, the work ought to be carried out by a steel maker. High quality steel could be made as satisfactorily in the electric furnace as in a crucible or in the open-hearth furnace.

Mr. H. Dodo found the tables in the paper very interesting, and attached great importance to the high tensile test figures referred to by the author.

Professor A. McWilliam asked the author what was really meant by the statement to the effect that with a correct slag killing agents were not necessary. He thought that actually the general experience would be found against that statement. Whatever care might be taken it would be found necessary to use some killing agents, and he asked the author to take up that point carefully.

Mr. Carlisle, in the course of his reply, said he quite agreed that basic open-hearth steel could be made quite as good as electric steel; in a recent paper read before the Institute it had, however, been said that the sulphur in the basic steel could only be made low by a great deal of lost time, and was not, commercially, a good proposition. In the electric furnace, on the other hand, the sulphur and phosphorus could be made low more easily than in the open-hearth furnace. He agreed also that the sulphur in the slag existed in part as sulphate. He had analysed his slags and had found that the total sulphur was not present wholly as sulphide. Geilenkirchen also said that the existence of sulphur as SO_3 was only a transitory stage. Calcium carbide was not a panacea for all evils, and one could get a good slag without it being in preponderance. Silicon acted in the same way as calcium carbide.

The other papers on the list were taken as read, and discussion on them will be given by correspondence. On the motion of the Chairman, all the authors received the thanks of the meeting for their contributions.

The proceedings terminated by a vote of thanks to the Lord Mayor and Corporation of Cardiff for their cordial reception, to the South Wales Institute of Engineers for the loan of their premises, and to the various works and installations in the district for the invitations they had extended to the members for visiting their plant.

NOTES.

Some Observations on the Industrial Fatigue Research Board.

There has just been published No. 8 of the Reports of the Industrial Fatigue Research Board. It is entitled "Some Observations on Bobbin Winding," and we are indebted to it for suggesting the title of this note. The Report is of 40 pages. What they contain we can indicate very briefly. Bobbin winding in the cotton industry consists in winding yarn from the tubes on which it is spun, on to bobbins in order to facilitate warping, which is the next process in the progress from raw cotton to calico, or whatever it may be. The Report tells us that the American type of bobbin winding frame, which is more compact than the English type, involves less stretching and stooping on the part of the operators. It also tells us that at a certain mill in South Lancashire (not specified by name) there is no evidence that the women employed in the bobbin winding depart-

ment suffer from excessive fatigue, either towards the end of the day or at the end of the week. It also tells us that the department is the most efficient in the mill, but that the ventilation and lighting are somewhat defective, and that each employee loses on the average two hours' work a week owing to defective transport of material through other parts of the mill. Forty pages are employed in imparting this information, and what we are concerned with is to inquire why it was considered necessary to publish the matter at all—at the public expense, we presume. The Report states that it deals only with a small side inquiry, but it does not state that the inquiry resulted in nothing at all of any importance. The investigation of industrial fatigue is an important matter, but if the Board concerned is going to publish all its preliminary and slight investigations, the result will be discredit and the refusal of any one to pay any attention to its Reports, important or not.

The Employment of the Blind in Engineering Shops.

Since the war came on us we have had the employment of the blind kept before us as a result of efforts on behalf of those who lost their sight in the service of the country. Although perhaps not to be recommended as common practice, it is interesting to note that, quite apart from the after effects of the war, blind men and women have been employed in engineering workshops with a considerable degree of success. The *Iron Age* recently published an article on what has been done in Cleveland, Ohio, in this direction. It is stated that about 70 operations in engineering shops are now performed in that city by blind men and women. These include the operation of machine tools, including broaching machines, drills, grinding machines, lathes, punching machines, stamps, spot welders, nut-facing machines and so on. On bench work such hands have been employed on cleaning castings, nutting bolts and packing. The electrical trades furnish a good many opportunities in, for instance, taping field coils, stator, magneto and other forms of coils; in the assembling of small electrical gear, such as switches, while in the assemblage of locks, radiators, sewing machine parts and other light work the blind are now successfully employed. Such employees are working at these selected jobs at the same piece work rates as normal workers, and are making as much money in spite of the loss of this faculty. The blind worker is said to be steady and reliable. Their natural caution has resulted so far in an absence of accident. Although the placing of such hands in engineering works naturally needs the most careful consideration in the selection of work and surroundings suited to their conditions, their sphere of labour is certainly not so limited as it was once deemed to be, while in output they have shown themselves capable, when well placed, of competing with and often exceeding the efforts of the ordinary hand. The results of Cleveland should encourage the study of this problem on this side in connection with our war cases.

Longitude Determination by Lever Watches.

In connection with the precision lever watches of M. Paul Ditisheim, of La Chaux-de-Fonds, Switzerland, to which reference was made in our issue of May 28th last, a series of tests was made recently to discover how closely simple lever watches could approach to the accuracy of wireless telegraphy in longitude determination. The tests were arranged between Paris and London, and the watches were conveyed by aeroplane in order to shorten the period of transit and thus improve the accuracy of the determinations. On account of bad weather the first journey, undertaken on May 18th, was abnormally long, occupying about seven hours, but in the subsequent journeys, undertaken between May 21st and May 27th, the average time was only 2·45 hours. On one occasion the watches were taken forwards and backwards in one day. The watches were compared at Greenwich by Mr. Bowyer and in Paris by M. Lancelin, who also made the general calculations. Twelve watches were used, and the various journeys afforded 61 observations. The average of these has proved to be within 0·005 of a second of the average of the standard wireless determinations. This difference is so minute as to be negligible. These results confirm previous experiments between Neuchatel, Bordeaux and Washington, which showed that the lever watch could be produced in a robust form and yet be capable of the highest degree of accuracy. The watches used in these tests were similar to those which had obtained the record marks of 96·9 out of a theoretically possible 100 in trials at the National Physical Laboratory, Teddington. In a recent statement to the Academy of Sciences, Paris, Mr. Ditisheim stated that it was the organisation of a regular aeroplane service between Paris and London which induced him to make a new determination of the difference in longitude by means of lever watches in order to discover the limit of precision which could be reached in actual manufacture. The watches, which are about 2½ in. in outer diameter, were wrapped in wool to protect them from the extreme cold, and were kept horizontal during the journey. Otherwise no special precautions were taken.

Interfacial Tension Mercury–Oil.

During recent discussions on lubrication Southcombe and Wells described their method of determining the interfacial tension between a lubricating oil and water by discharging the oil from a capillary, bent upward, into water and by counting the number of drops rising in a certain time. They also mentioned that Professor W. McC. Lewis had measured the surface tension between oil and mercury and had observed that the addition of about 2 per cent. of fatty acid to the oil lowered the surface tension between the oil and mercury, *e.g.*, from 100 to 89. Further experiments on this interfacial tension have been made by Shanti S. Bhatnagar and W. E. Garner at Liverpool (*Journal of the Society of Chemical Industry*, July 15 last), the method being that applied by Professor Donnan, then at Liverpool, in 1899. Drops of mercury are allowed to fall from a capillary into the oil or solution, the capillary dipping into the liquid. The sizes of the drops and their weights vary with the nature of the oil and, according to Rayleigh, the surface tension is directly proportional to the weight of the drops. The experiments are so arranged that the fine capillary does not allow more than two drops to escape per minute; the drops settle in a glass cup or spoon which is placed at the bottom of the vessel containing the oil. When 50 drops or more have collected, the spoon is taken out of the oil, the mercury is washed with carbon tetrachloride, and the mercury is weighed. To test the influence of the addition of fatty acids to other oils, pure paraffin oil (of high viscosity, high boiling-point and definite composition) was selected as reference material and solvent. The organic acids dissolved in this oil were oleic acid, stearic, linolic and palmitic acids. The surface tension paraffin oil-mercury being taken as 100 dynes per centimetre, it was confirmed that the surface tensions in all cases decreased as more and more acid was added to the oil. With concentrations of 1·2 per cent. the interfacial tension of the oleic acid solution sank to 94, whilst that of the linolic acid solution sank to 90; the other two acids approached with increasing concentration the curve of the oleic acid, but the experiments were not carried to the higher concentrations. The oleic acid differed from the others in so far as the diminution of the interfacial tension was at first very slow, and began to drop off rapidly at a concentration of 0·25 per cent., whilst in the case of other acids the diminution was fairly regular from the first. This peculiar behaviour of the oleic acid may be connected with Langmuir's observation that the thinnest surface film of oleic acid is only half as thick as a film of stearic or palmitic acid, and it would appear that the increased efficiency of a lubricating mineral oil, to which an organic acid has been added, really runs parallel with the lowering of the tension at the metal-oil interface. The experiments should, of course, be made with oil and steel or some solid metal at any rate; as that is impossible, the liquid metal mercury is used.

Acetylene for Automobiles.

During the latter part of the war acetylene-driven automobiles were tried in Switzerland with the approval of the Government, as the country makes calcium carbide, but has to import petrol. We noticed these experiments on page 469 of our issue of October 25, 1918. The trials do not appear to have proved promising under normal conditions. When Professor F. Haber visited Zürich in autumn, 1919, he could not find a single acetylene automobile; they had all been reconverted. From a book by Professor C. F. Keel, director of the Swiss Acetylene Society, on "Acetylen im Automobilbetrieb" (Zürich: Rascher and Co.), he learnt that acetylene propulsion was about half as expensive as benzol propulsion, when the acetylene was generated from carbide on the automobile. By request of the German Government, however, he has investigated the possibility of acetylene as motor fuel, experimenting, in conjunction with Kerschbaum and Tesch, with a stationary motor of 4 h.p. (normally driving a dynamo) and a Fiat automobile of 20 h.p. According to Keel, 1 kg. of acetylene gave as much energy as 2 kg. or 2·5 kg. of benzol, though the heats of combustion are only as 1·2 : 1. The reason for this, Haber found (*Zeitschrift für Elektrochemie*, August last, pages 325 to 329) to be that there is always an excess of air in the benzol fuel mixture, whilst acetylene can be burned with its theoretical air allowance. When the motor was run with benzol by expert chauffeurs on level ground, the exhaust contained 6 per cent. or 7 per cent. of CO_2, and 14 per cent. of CO; while running up hill at a slower speed the exhaust contained 7 per cent. to 8 per cent. of CO_2, 8 per cent. or 9 per cent. of CO, and further 2 per cent. of hydrogen. The combustion of benzol was thus incomplete; in tests that of acetylene proved to be complete. In the experiments of Keel, which favoured acetylene, the motor had been run for maximum power, but not for best fuel efficiency. As regards the variation of the acetylene percentage in the air mixture, Keel stated that owing to the high pressures and temperatures produced in the cylinder, the admissible limits ranged from 1·5 per cent. to 7·5 per cent. of acetylene; Haber sets these limits at 3 per cent. and 5 per cent. With mixtures too poor in acetylene, there was noisy back-firing; with rich mixtures, pinking. The pinking is generally ascribed to spontaneous pre-ignition of the mixture by the compression. Haber investigated this by driving his stationary internal-combustion motor by the dynamo (acting then as electric motor) so that the stationary motor itself served as a gas pump, the Bosch magneto being cut out. These and other experiments showed that pre-ignition was not due to the compression, but to the over-heating of the gas mixture by the insulation of the plug electrode; the insulating material cools less rapidly than the metal parts, and, when the insulation projected into the ignition zone, pre-ignition was observed to take place earlier, according to the richness of gas in the acetylene. When rich acetylene mixtures are to be used, the cooling water should be kept especially cold or water should be injected into the cylinder. The injected water then cools directly, and also indirectly by diluting the acetylene; such a colder mixture is less liable to pre-ignition. It is difficult, however, to get the maximum power with pure acetylene, because a third of the air, not really required for the combustion, is dragged as ballast through the engine, and the admixture of some other fuel is hence advisable. The fuel is then less ready to ignite and gives more heat per unit time without pinking. On these experiments, and also on the quantity-regulation by the Kerschbaum throttle-mixer a further communication is promised. By this device the quantity of fuel mixture is varied, whilst the quality—the percentage of acetylene—is kept constant. Since the adoption of this regulation, instead of varying the acetylene admission with a constant air feed, the Fiat motor has run well on acetylene fuel.

Machinery and Shipbuilding Requisites for Nantes.—As the result of a circular addressed to the industrial and commercial "Syndicats" of Nantes by H.M. Consul at Nantes, with a view to securing business for British firms, information has been received that the president of a "Syndicat" would be pleased to receive names of English merchants who could enter into relations with firms belonging to his "Syndicat," correspondence to be preferably in French. British firms, therefore, interested in the supply of machinery or shipbuilding requisites can be furnished with the name and address of the "Syndicat" on application to the Department of Overseas Trade, 35, Old Queen-street, S.W. 1, at the same time quoting the reference number, DOT/4609/F.W./P.N.

THE ROYAL AGRICULTURAL SOCIETY'S TRIALS OF AGRICULTURAL TRACTORS AND PLOUGHS.

The trials of agricultural tractors and ploughs, carried out under the auspices of the Royal Agricultural Society, which commenced on the 28th ult. afford a very instructive demonstration of the capacities of the various classes of machines. There are seven classes affording scope for every type of machine, from the smallest self-contained plough to the double-engine ploughing set. Classes 1, 2 and 3 are for direct traction internal-combustion engines not exceeding 24 h.p. and 30 h.p. respectively in the classes 1 and 2, and exceeding 30 h.p. in class 3. The horse-power is determined by a formula based on the declared revolutions and the piston area and stroke. Ploughs are standardised for each class, the number of furrows, &c., varying in the different classes to allow for the different power.

The method of classification by such a formula seems open to improvement, as it is impossible to ensure that the competitor will actually run his engine at the revolutions declared. It is thus possible for a competitor to put identically the same engine into two different machines and rate them at different powers so as to get them into different classes. In fact, it is interesting to note that the Austin Motor Company has a machine entered in class 1 and another in class 2, the description of which is identical, with the exception of the stated revolutions and, consequently, horse-power. In practice this objection may not be serious, and it will afford makers a chance of putting their vehicles into the class the ploughs of which are most suited to their powers.

The whole question of the classification of engines is, however, a very difficult one. If based on cylinder dimensions only the extreme high speed engine gives the best results, although it is obviously the least suited for practical work. The only practical alternative appears to be to classify on the weight of the vehicle, and there are certain objections to this, especially in the case of trials of experimental machines, as the weight cannot be accurately ascertained till the vehicle is finished.

Further classes are No. 4 for direct-traction steam plant, No. 5 for double-engine internal-combustion sets, No. 6 for double-engine steam sets, and No. 7 for self-propelled ploughs for not more than four furrows, 10 in. wide and 8 in. deep. The last class might have been hoped to produce a great variety of entries, including really small machines, but all the vehicles actually entered appear to be of moderate size, all ploughing either two or three furrows, the lowest declared weight being 3,360 lb. and the highest 5,600 lb.

Forty-six entries were received, and on the 27th all except four had actually arrived on the ground—an unusually large proportion. Class 2, for tractors under 30 h.p., ploughing three furrows 10 in. wide, is the most popular, there being 22 entries in it. Class 1, for tractors under 24 h.p., to plough two furrows, has ten entries; while class 3, for tractors over 30 h.p., to plough four furrows, has only three. It appears, therefore, to be considered that the tractor should be confined to a moderate-sized machine not ploughing more than three furrows, and this is probably a sound conclusion.

Classes 4 and 6, for steam engines only, produced one entry each, while class 5, for double-engine, internal-combustion, produced two entries. Class 7, for self-propelled ploughs produced seven entries. Taking a general survey of the machines on the ground we find they follow certain generally-defined lines. Among the tractors the first main division is between those on wheels and those on caterpillar-type tracks. These machines will probably both find uses, but will be suitable for different purposes. Where it is practicable to use wheels the upkeep will certainly be lower than that of a track machine, as the wear and tear on the track of the latter is bound to be considerable. The track has a considerable number of pin joints which run close to the ground and therefore get lubricated principally with mud and dirt. On the other hand, there is no doubt that the caterpillar type of machine will travel on land which the wheeled type will not go over at all, and it will therefore serve purposes which the latter cannot.

There is an alternative to either the ordinary wheeled vehicle or the track type which may develop in the future, but of which there is only one representative apparently in the present trials, namely, the machine which drives all the carrying wheels. This principle has been developed to a certain extent in motor vehicles, lorries driving all four wheels having been used for hauling howitzers in the late war. It was found that such vehicles were a great improvement on the ordinary lorry in going over bad ground for the reason that the front wheels were converted from being a liability into an asset. In other words, the ordinary vehicle has to push the front wheels along, whereas in the four-wheel drive the front wheels help to propel. With good spuds on the wheels and the latter of suitable diameter and width very bad ground indeed can be dealt with, the results actually approaching those attainable with the caterpillar type.

In detail, tractors fall into two general types: (1) Those in which the whole of the machinery is built up in one block of castings, which therefore take the place of the frame. (2) Those in which there are separate units carried on a frame. The former should be a good deal the cheaper to manufacture, and therefore if it is equally efficient will probably come into general use. There are many examples of both types on the trial ground.

Although the engines operating by direct traction will undoubtedly have a large field for their work it seems probable that there will still be a considerable future for the double engine set, which has many advantages in suitable places. It should manifestly be more economical for the engine to stay still and pull the plough with a rope, rather than that the engine and plough should both be moved. In addition an engine will move itself along a headland when the ground is so bad that a plough could not be pulled direct across the field. The difficulty anticipated by some of the land being damaged by the passage of the engine over it is also overcome by the double engine system. Three sets of double-engine ploughing tackle are entered, and all are on the ground.

Messrs. John Fowler and Co. (Leeds), Limited, have a steam set which is of their well-known pattern, but is distinctive in that it is of the simple, single-cylinder type in place of the compound to which we have got accustomed. The steam is superheated and a piston valve is used. It will be interesting to see the results of this in practice, for although it seems a retrogade step, it is quite possible that for work with such varying loads and speeds as traction and ploughing a good non-compound engine supplied with superheated steam will show practical results as good as a compound-engine, taking wear and tear, &c., into consideration.

Of greater interest are the two double engine sets of the internal-combustion type, constructed by Messrs. John Fowler (Leeds) and Messrs. J. and H. McLaren respectively. The former is a powerful machine each unit being a 60-h.p. petrol engine of conventional type mounted in the usual position in front with the shaft longitudinal. The winding drum is underneath the vehicle in the position familiar in the Fowler steam ploughs. The total weight is 6¼ tons. The general lay-out is on motor car lines, but the proportions, &c., are much in accordance with traction engine experience. An electric self starter is provided so that each engine can be stopped while the other is pulling. The whole appearance of the plant is very workmanlike and substantial.

The McLaren set is a very much lighter machine, each unit having a 32-h.p. engine mounted across the front. This drives a countershaft at a reduced speed and from this a countershaft at the back of the vehicle is driven by a long chain. From this countershaft the winding drum is driven by spur gear and the driving wheels by bevel gear and worm. The drum is therefore mounted on a shaft across the vehicle and the rope is led round a pulley underneath it to get a fairlead to the plough. The whole is on a very much lighter scale than the Fowler, the weight being 3½ tons.

This ploughing set also has arrangements for each engine being stopped while the plough is being pulled by the other engine. In place of an electric self-starter however, arrangements are made to connect each engine by a clutch to gear driven by the winding drum. When the driver, therefore, observes that the plough has nearly reached the other engine he uses this method to restart his own.

Where ploughing can be done on a large enough scale it seems that such engines as those above described may have a good field for reasons given above, and for many purposes the internal combustion engine has undoubtedly great advantages. Large fields suitable for double-engine ploughing are often found on the tops of hills where there is great lack of water. Under these circumstances steam ploughing is impracticable as it has to be done on a large scale in order to pay, and this means powerful engines which use an enormous quantity of water, and the provision of this water is a difficult matter. It is only in quite exceptional parts of England that large fields are found combined with a good water supply, and it is this difficulty of getting water to the engines which has largely killed steam ploughing in many districts. A combination of the good points of the double engine steam plough with the internal combustion engine needing practically no water might thus in such cases be very successful indeed. At the same time it appears doubtful whether small sets of this type will pay. The labour costs are the same for a powerful engine ploughing many furrows as for a light engine ploughing few, and as the engine only goes along the headland its weight within fairly wide limits is little objection.

It seems rather a pity that in connection with the trials now in progress arrangements are not made whereby the public can see more of the construction of the various competing machines. As there is a very great amount of room in the aerodrome where the vehicles are parked it seems that it might be possible to arrange some sort of stands at which makers representatives could explain the chief constructive features of the various vehicles entered for the trials. To those who take an intelligent interest in the development of agricultural machinery this provision would afford really valuable information.

The trials, which are being carried out at Aisthorpe near Lincoln, began, as we have stated, on the 28th ult. in the very best of weather on the light land at the top of the chalk wolds. Very good progress was made, for there were enough ploughs, &c., provided for all the machines in classes 2 and 5 to be put to work at once. No results will be published by the committee till the trials are finished, but it appeared that all the machines in these two classes completed their light ploughing without any important incident. On Wednesday last, the 29th ult., the trials were continued on the light land, and the competitors in classes 1, 3, 4, 6, and 7 did their ploughing. Practically all the machines completed the work given them without difficulty.

The weather up to the time of our writing, has been brilliantly fine and the land, therefore, very dry. As it is very light land situated at the crest of a hill the ploughing has been very easy and has hardly been any real test of the engines, though it will, of course, give comparative results as to speed, fuel costs, &c., which will be published later.

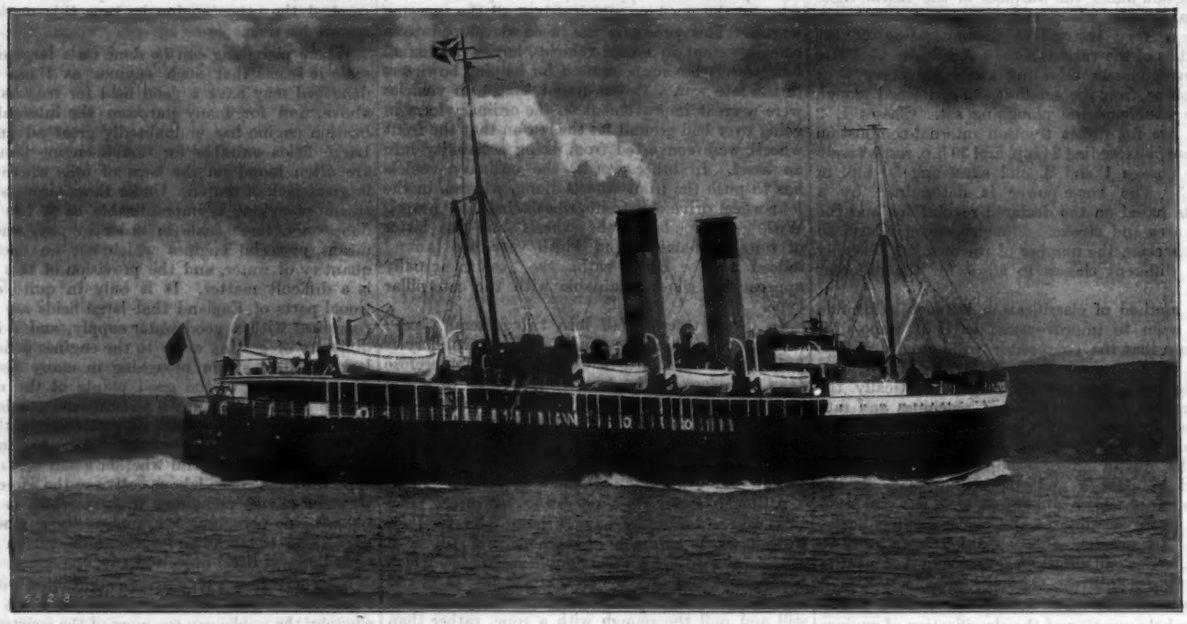
The machines will be more severely tested in the heavy land, the trials on which began yesterday, the 30th ult. Although the fine weather is a great benefit to those who have to be present at the trials there would have been more technical interest if there had been some good heavy rain to make the conditions more severe.

(To be continued.)

Trials of H.M.S. "Raleigh": Erratum.—In the article on the trials of H.M.S. Raleigh which appeared in our last week's issue, page 418 *ante*, we stated, near the foot of the third column, that auxiliary steering gear of the Hele-Shaw type was installed in the vessel. We have since been informed that the complete auxiliary steering gear was supplied by Messrs. Brown Brothers and Co., Limited, Rosebank Iron Works, Edinburgh, and is of the Williams-Janney-Brown electro-hydraulic type. We regret the mistake made.

TWIN-SCREW CHANNEL STEAMER "BRUGES" FOR THE G.E. RAILWAY SERVICE.

CONSTRUCTED BY MESSRS. JOHN BROWN AND CO., LIMITED, CLYDEBANK.



The twin-screw turbine Channel steamer Bruges, of which we give a view above, has just been added to the fleet of the Great Eastern Railway Company. This steamer has been built by Messrs. John Brown and Co., Limited, Clydebank, who also provided the propelling machinery, &c. This vessel has been designed for the Harwich-Antwerp service, and in addition to passengers, has accommodation for horse traffic. Her principal dimensions are: Length on water line, 330 ft.; breadth, 43 ft.; depth to shelter deck, 26 ft. 6 in. She is built to Lloyd's special class. The passenger accommodation allows for 263 first-class and 102 second-class passengers being carried.

The first-class dining saloon on the shelter deck forward has seating accommodation for 72 passengers, and is decorated in the Georgian style, the walls being painted grey and white with the doors of polished mahogany. An electric "Magicoal" fireplace is arranged at the fore end. Turkish rugs are laid over an oak parquetry floor and sofa seats and chairs are upholstered in tapestry. The first-class smoke-room is situated on the shelter deck between the forward and after funnel casings. It has a large domed skylight with leaded glass. The decorative style is Jacobean, the woodwork being in oak and upholstered in dark blue morocco. A feature of this room is a fireplace of Hopton wood stone with an armour bright grate on a brick red-tiled hearth. The first-class ladies' room, situated on the main deck port side, is decorated in white with silk tapestry panels, and is fitted with a "Magicoal" fireplace at the forward end. The first-class lounge is situated in the deckhouse on the boat deck, in way of the first-class entrance and stairway. The walls and ceiling are white enamel. The first-class state rooms are arranged in one, two, three and four-berth rooms on the shelter, main and lower decks.

The second-class accommodation is arranged at the aft end of the ship; the cabins on the main and lower decks; the dining saloon, which seats 40 passengers, on the main deck, and the ladies' room on the shelter deck. The woodwork is finished in white enamel, while the sofas, chairs &c., are upholstered in railway repp. The second-class smoke-room is situated on the shelter deck aft. The floor is covered with inlaid corticene, and the sofas are upholstered in green pegamoid. The culinary arrangements are very complete, the main passenger galley being fitted up with an electrical installation comprising a large range, grill and toaster, in addition to the usual steam-heated appliances. Arrangements are made whereby 90 horses can be carried in separate stalls, and hatchways and gangways are designed to ensure safe handling and embarkation.

The propelling machinery consists of twin-screw Brown-Curtis geared turbines of the latest type, supplied by steam from five single-ended boilers of the cylindrical return tube type, and a small donkey boiler; the speed of the vessel with full deadweight on board was 21¼ knots on a trial of 6 hours' duration.

LABOUR TROUBLE: ITS IMMEDIATE CAUSE AND REMEDY.

To the Editor of Engineering.

Sir,—I regret not being ready with my answer to "J. C. R.'s" criticism of my proposal in your issue of August 13; but I have been informed that a certain North of England industrial association has for some considerable time been running an employment scheme similar to that I proposed, and with a certain measure of success. I am endeavouring to obtain some facts in connection with same, which, if I am successful, I trust you will allow me to lay before "J. C. R." and your other readers.

Yours faithfully,
"An Employer."

STRIKES.

To the Editor of Engineering.

Sir,—The strictures contained in your issue of the 17th inst. regarding strikes and the general conduct of workers in relation to wage questions, &c., induce me to express herewith an opinion as to another aspect of the situation. In your criticism, you adduce two primary causes, but it occurs to me that at least, in partial explanation of what we see enacted before us to-day, another cause may be considered to be at work.

Years ago, the two principal political parties never hesitated to invoke on their respective behalf the support of the working man's vote when elections were pending. This kind of manœuvre was bound ultimately to cause the veriest ignoramus to recognise that this undignified pandering would lead to swelled heads on the part of those who were pandered to. What is more natural—but that with time the workers recognised—their voting strength being in such urgent demand to tilt the political balance one way or another, they might as well combine amongst themselves, all the more so in view of the frequent non-materialisation of the promises held out to them by the contending parties, who were simply out for vote-catching. And not only this, but the most serious resulting evil is, that by solidarity amongst themselves and by forming their own party, they not only more likely succeed in what they are pressing for, but it has come to the point of enabling them to enforce demands in their more political aspect by the ultimatum of vast strikes affecting the very industrial and commercial fabric of the State.

These despicable election manœuvres always reminded me more of a game of football than anything else, with the two contending political parties as the teams, and workman's suffrage as the ball, to be alternately kicked or hugged. The many deflations of the ball in the shape of political disillusions have brought about its transformation into a very intractable compound, in fact into a third party of players, who now repay their former kickers in kind and decline to be hugged any more.

I hold no brief for any particular one of this modern trio, but the politicians have certainly used the workers merely for what a German would tersely call "Stimm-Vieh" (voting-cattle), and we are at the present time reaping the rotten harvest of warped political honesty and vote-catching. Neither can anyone wish for a moment to defend what is so obviously wrong in these chronic disputes and the harm they do to public and private business and life. And it is too late now for these political mountebanks and office seekers of the period complained of to express regrets, but let there be no mistake about their chickens having come home to roost.

On the other hand, if personal observation does not deceive me, and alas, I fear it does not, the workers have in many cases laid themselves open to the reproach that, in spite of reduced hours and increased wages, the productive power has not kept proportionate pace, and what makes it worse is that the quality of the work is so much inferior to what it was in pre-war times. There is a deplorable lack amongst workmen of taking the slightest personal interest in their masters' undertakings, of a voluntary loyalty and eagerness to make sure of their success, and this shortsighted conduct, if not checked, is not conducive to establish a prosperous future.

Very candidly yours,
"Neutral."

September 23, 1920.

The Failure of Metals under Internal or Prolonged Stress.—The Faraday Society, Institution of Mechanical Engineers, the Institute of Metals, and probably also the Iron and Steel Institute, contemplate holding, early in 1921, a joint general discussion on "The Failure of Metals under Internal or Prolonged Stress." While various aspects of the subject have already been discussed, some new matter will be placed at the disposal of the co-operating societies later in the year, and it is thought that this will afford an opportunity for a more comprehensive consideration of the subject than has yet been given to it. The problem to be discussed is the failure of metal articles as a result either of external stresses to which they have been exposed for any length of time, or of internal stresses arising from conditions of manufacture, such as cold work, unequal expansion or contraction during casting and subsequent operations, including rapid heating and cooling. It is intended that the subject of the discussion should include the phenomena known as "season cracking," "corrosion cracking," "fire cracking," and analogous forms of failure, and that iron and steel as well as non-ferrous metals should be dealt with. The scope of the discussion would permit of contributions relating to the properties and behaviour of materials other than metals which might throw light on the phenomena covered by the title. Anyone desirous of contributing to this discussion is asked to communicate with the Secretary of the Joint Committee, Mr. F. S. Spiers, 10, Essex-street, London, W.C. 2.

THE P. AND O. LINER "NALDERA."

(*Concluded from page 279.*)

HAVING described the general features of the P. and O. liner Naldera in our issue of August 27 last, on page 278, we now propose to conclude our account of the vessel by dealing with the propelling and auxiliary machinery. The former comprises two sets of quadruple expansion reciprocating engines by Messrs. Caird and Co., Limited, the builders of the vessel, to the specification of Mr. R. Leslie, the superintendent engineer of the P. and O. Company. In Figs. 16 and 17 on Plate LVIII, which accompanies this issue, we reproduce side and end elevations of the port set of engines, which, together with the corresponding starboard set, develop a total of 15,000 indicated horse-power when running at 90 r.p.m., and supplied with steam at 215 lb. per square inch in working pressure. This power is sufficient to give the ship a speed of about 18¼ knots. There are no very unusual features in the design of these engines, but the drawings on Plate LVIII are nevertheless well worthy of careful scrutiny by students of marine engineering, since the engines form an excellent example of modern practice in this class of machinery.

The diameters of the cylinders are all given on Fig. 16, so that they need not be repeated here, but it should be stated that the piston stroke is 5 ft. in each case. Fig. 16 also shows the arrangement of the cylinders, and it should be noted that the high pressure cylinder, which is placed as usual at the forward end, is followed by the low-pressure cylinder. Adjoining this is the second intermediate cylinder, while the first intermediate cylinder is situated at the after end. The castings forming each cylinder and steam chest are kept separate, but the cast-iron box columns on which they are supported are connected by box-shaped beams at their upper ends, as shown. The hollow space inside the columns, it may be mentioned, is utilised for the storage of lubricating oil.

Steam distribution to the high-pressure and first intermediate pressure cylinder is controlled by a single piston valve in each case, while two similar valves are employed for the second intermediate-pressure cylinder and a double-ported, flat slide valve is used for the low-pressure cylinder; all the piston valves work in cast-iron liners. The valves are all operated by double bar link motion and the travel of each is given on Fig. 16. Reversing is effected by a Brown direct-acting steam and hydraulic engine shown to the left of the column supporting the low-pressure cylinder in Fig. 16, and also indicated by dotted lines near the right-hand bottom corner of Fig. 17. This figure also shows the design of the crossheads and guides. The latter, it should be mentioned, are all water-cooled, while the crossheads are fitted with double shoes of cast-iron lined with white metal. The engines are balanced on the Yarrow-Schlick-Tweedy system, and the crankshaft runs in seven bearings. The bedplate is of box form cast in sections and bolted together as shown in Fig. 16. The thrust blocks, which are of the usual type and have 14 collars each, are bolted to the engine seating, but are separated from the bedplate. The propeller shafting of forged ingot steel is 19½ in. in diameter, and the propellers are 19 ft. in diameter and of 24 ft. pitch. Each propeller has three blades of manganese bronze, the surface of each blade having an area of 92·75 sq. ft.

The main condensers, which are mounted on the engine columns, as shown in Figs. 16 and 17, are of the Weir "Uniflux" type, each having a cooling surface of 7,500 sq. ft. The condensate is handled by "Dual" air pumps, also by Messrs. Weir, and the cooling water is circulated in each condenser by two Tangye centrifugal pumps. With cooling water at a temperature of 83 deg. Fahr. the whole plant is capable of maintaining a 26-in. vacuum. There are three Weir double-acting feed pumps working in conjunction with a direct contact heater by the same firm, and the feed make-up for the main boilers is supplied by two evaporators each having a capacity of 40 tons daily. The remaining auxiliaries in the engine room, all of which are independent of the main engines, include the usual ballast, bilge and sanitary pumps, a fresh-water pump, main and auxiliary feed-water filters, and a waste oil pump which draws oil from the tunnel bearings.

Steam is generated by 10 boilers of the ordinary marine type arranged in two boiler rooms, as shown in the plan of the orlop deck, Fig. 10, on page 279, in our issue of August 27 last. The forward boiler room contains four single-ended and two double-ended boilers, while the after boiler room contains two double-ended and two single-ended boilers. The double-ended boilers are each 16 ft. 6 in. in diameter by 20 ft. long, and have four furnaces at each end, while the dimensions of the single-ended boilers are 15 ft. 2 in. in diameter by 11 ft. 9 in. long. The latter have three furnaces each, so that there are 50 furnaces in all, with a total grate area of 958 sq. ft. The total heating surface of the 10 boilers is 39,628 sq. ft. The boilers, which are designed for a working pressure of 215 lb. per square inch, work under the Howden system of forced draught, air being supplied by four fans each driven by a separate electric motor. There are also four 42-in. electrically-driven fans for ventilating the engine and boiler rooms, and the engine-room fans are arranged so that they can be used either to deliver air to or extract it from the engine room. Two Stone's hydraulic ash expellers, the water for which is supplied by a turbine-driven pump, are fitted, and an ash hoist is also provided in each boiler room.

The electric generating plant is situated in a recess at the after end of the engine room, and consists of six Bellis and Morcom compound engines driving Siemens generators. The entire plant has an output of about 280 kw. at 105 volts, and was supplied by Messrs. Siemens, Brothers, Limited, who carried out the whole of the electrical installation. This includes some 3,000 lamps and over 800 cabin fans, as well as electrically-operated lifts, galley machinery and gymnasium appliances. An emergency generating set driven by an oil engine and having an output of about 15 kw., is mounted on the promenade deck. This set supplies power to a motor driving a two-throw pump, which can be used for pumping out the bilge in case of emergency. On the orlop deck, at the after end of the engine-room, a Haslam duplex CO_2 refrigerating machine is installed for cooling the provision chambers, and a larger machine, of the same type, is situated on the lower deck near the forward end of No. 1 boiler-room for cooling the insulated cargo spaces. The steering gear is installed in the after peak on the lower deck, and it comprises a steam tiller controlled by telemotor from the bridge or by hand gear from the after end of the promenade deck. A hydraulic auxiliary steering gear is also provided.

The Naldera left Tilbury on her maiden voyage to India and Australia on April 10 last, arriving at Sydney on May 24 without any noteworthy incident. The return journey occupied from June 8 to July 6. In conclusion we may remind our readers that Messrs. Caird's shipbuilding yard was acquired by Messrs. Harland and Wolff, Limited, some few years ago, and as the Naldera is the eighty-fifth vessel built at the Greenock Yard for the P. and O. Company, and a number of important P. and O. ships have also emanated from the Belfast Yard, the ship may be regarded as a connecting link between the two firms.

CLEANING BLAST-FURNACE GAS.

*Rough-Cleaning of Blast-Furnace Gas at Skinningrove by the Lodge Electrostatic Process.**

By A. HUTCHINSON and E. BURY, Skinningrove.

PREFACE.

THE ultimate rough cleaning of blast-furnace gas at Skinningrove for use in stoves, boilers and other combustion processes has always been an essential consideration during the last ten years as making for fuel economy in the production of iron and steel. If a process could be found whereby the gas could be adequately cleaned for combustion processes (excepting, of course, the gas-driven power station) without loss of the sensible heat contained in the blast-furnace gas, it was considered that a valuable fuel asset would be secured towards making the iron, steel and by-product coking plant self-contained from the coke carbonised in the latter. The other palpable advantages to be derived from using cleaned gas are as follows:—

1. Greater thermal efficiency at the stoves, boilers and other furnaces where the cleaned gas would be utilised, by preventing heavy deposits in flues, checkers and regenerators.

2. More profitable use of capital in obviating the laying-off of plant for cleaning.

3. Reduction in labour employed for cleaning stoves, boilers and checkers.

4. The preservation of the firebrick construction from attack by alkalies contained in the blast-furnace dust.

5. The saving in gaseous fuel consumed at the aforementioned plant by the greater thermal efficiency of the blast-furnace gas.

In seeking these economies the main difficulty lay in the fact that existing rough-cleaning processes did not economise the sensible heat in the blast-furnace gas which it was desired to preserve. In the case of water-washing processes, not only was the sensible heat in the gas lost, but further fuel had to be expended in pumping the huge volumes of water required for the dust removal. In the case of filter cleaners employing filtering media of combustible textile fabric, the gas had likewise to be cooled to prevent damage to the filters and then reheated beyond its dew-point to prevent deposition of slime upon the filters, which would otherwise become choked. In both types of cleaner fans had to be employed for forcing the gas through the plant, involving a further expenditure of power in fuel.

HISTORICAL.

Under the above circumstances it was decided to postpone the question of rough cleaning until some process was devised which would provide against the above-mentioned disabilities—that is to say, a process which would economise the sensible heat in the gas and, further, would minimise the fuel absorbed in pumping water and in moving the gas through the cleaning system.

During the latter period of the war the matter again presented itself very forcibly for consideration on two counts:—

1. The use of electrostatic methods in America for the precipitation of chemical and metallurgical fume, and in Great Britain for the precipitation of sulphuric acid fume at H.M. explosive factories.

2. The national shortage of potash, which during 1916 had been proved to be present in the blast-furnace dust at Skinningrove in considerable quantities.

The possibility of cleaning dusty gases by electrostatic discharges had been raised by Sir Oliver Lodge as far back as 1882 and more recently. Thwaite had conducted successful electrostatic experiments with blast-furnace gas at Seaton Carew. Dr. J. E. Stead had likewise discussed these possibilities at Skinningrove with the late Mr. T. C. Hutchinson, managing director; but the matter was not gone into further until Sir A. B. Gridley, Director of Electrical Supplies at the Ministry of Munitions, called attention to the success which had attended electrostatic precipitation in the United States, which, however, had only been applied in that country on a very small scale to blast-furnace gas. The authors thereupon discussed the possibility of the successful application of electrostatic methods for Cleveland blast-furnace gas with the late Mr. Greville Jones of Port Clarence, and together finally decided that Messrs. Bell Brothers and the Skinningrove Company should erect a semi-large-scale plant at Skinningrove employing the discharge system invented by Sir Oliver Lodge. The plant designed for these trials was erected and put to work early in 1917, and consisted of two nests of vertical pipes in series, after the manner of a tubular condenser. In the centre of each pipe was suspended a vertical rod on which horizontal discs were placed at intervals of 6 in. The discs were cut radially from the centre and the segments twisted propeller-wise, in order to give a maximum edge for discharge. The electric discharge, 40,000 volts, was passed through insulators to the vertical rod, and thence through the discs to the inner surface of the pipe. The gas was passed between the periphery of the discs and the surface of the pipe, thus coming under the influence of the discharge, the dust deposit taking place upon the pipe surface.

The quantity of gas passed through this apparatus was varied from 40,000 cub. ft. to 80,000 cub. ft. per hour, according to the degree of cleanliness required in the gas issuing from the apparatus. The cleaned gas contained from 0·2 gramme to 0·5 gramme per cubic metre according to the rate of flow, the dust content on the dirty gas being 4 grammes to 5 grammes per cubic metre. These experiments were conducted on gas from the downcomers, under normal furnace conditions of temperature, pressure, dust and water content, &c., and convinced the authors that the method could be successfully applied on the large scale, if due regard were paid to careful direction of the gas flows over the discharge surfaces, with a similar regulation of the electric discharge from all points. Their conclusions were shared by Mr. Greville Jones, whose collaboration they had the misfortune to lose through death, shortly after the completion of this series of experiments. The investigation was carried out over a period of three months, upon which it was decided to erect a plant for the treatment of the entire make of blast-furnace gas, *i.e.*, from 3,000 tons to 3,500 tons of pig-iron per week.

GENERAL CONSIDERATIONS.

In the design of the large-scale plant, very little data existed as a guide beyond the vital importance of carefully regulated gas and electric flow and a maximum speed limit of gas flow of 3 ft. per second. Furthermore, there was no standard degree of gas cleaning which could be fixed to guarantee clean stoves, boilers and checkers. In determining the size of cleaning plant to be employed, it was for obvious reasons desired to keep the capital expenditure within the limit required for rough cleaning, bearing in mind that the Theisen plant for the gas-driven power station at the works was already in existence and would always have to be employed to wash and cool the proportion of the gas required for that purpose. All that was necessary, therefore, was to clean the gas adequately for stoves, boilers and other furnace work, and for these purposes 0·3 gramme of dust per cubic metre in the cleaned gas was ultimately fixed as an arbitrary standard. Recent investigation at Continental works, where rough water washing for stove and boiler use is almost universally employed, has shown that the desired end can be obtained by a higher dust content in the cleaned gas, instances being on record where stoves had not been cleaned for five years with a dust content of approximately 1 gramme per cubic metre in the water-washed gas. The arbitrary standard of 0·3 gramme per cubic metre was therefore well on the safe side, and there would be no point in increasing the capital expenditure on plant with the object of reducing the dust in the gas to below that figure, so far as boilers, stoves and furnaces were concerned. Since the start of the full-sized electrostatic plant at Skinningrove last Easter, the dust content has been reduced from 5 grammes to 6 grammes per cubic metre in the raw gas to 0·8 gramme to 1·1 gramme in the cleaned product, at which figure no deposit of dust has taken place in the flues since the plant started work. It should be specially mentioned that this result has been attained with 15 per cent. to 20 per cent. of the electrostatic plant out of action owing to difficulty in obtaining electrical equipment, spare transformers, &c. With the complete plant at work it is expected to maintain the dust in the cleaned gas at 0·5 gramme

* Paper read before the Iron and Steel Institute at Cardiff, on Wednesday, September 22, 1920.

to 0·7 gramme per cubic metre, which will serve amply the purpose for which the plant was erected.

In the foregoing, reference has been made to the vital necessity of carefully regulated gas flows as being essential to successful electrostatic treatment—a statement which demands great emphasis. It has to be remembered that in this method of gas cleaning the gas passes without restriction of any kind through nests of rods and plates, which are perfectly open and offer no resistance to this gas as in the case of filters or powerful sprays of water. The danger of gas slipping through the treatment chambers uncleaned is therefore much greater in electrostatic methods than is the case with water spraying or filtration plant. Recognising this difficulty, the electrostatic plant at Skinningrove was designed to split up the gas make and flow through 16 cleaning units, further subdividing the flow in each chamber through adjustable bafflers, so that the gas would flow evenly over the discharge grids both in horizontal and vertical planes. As a further precaution the inlet of each chamber was designed so as to deliver the gas equally over the vertical and horizontal planes of the discharge surfaces, a similar arrangement being adopted at the chamber outlet in collecting the gas for delivery into the clean gas main. It was elected to regulate the flow of gas through each chamber by adjusting the outlet valve which, being clean, would not clog up and upset the gas flows.

Of equal importance is the equalisation of the electrostatic field throughout the chambers, since any short-circuiting would militate against equal treatment of the gaseous atmosphere. The Lodge Fume Company, who are responsible for the electrical equipment of the plant, have provided against this eventuality by supplying each chamber with two sets of discharge grids in series, each with its own transformer set. Each set of grids is provided with 7,000 discharge points, that is 14,000 points to each chamber, so the electrostatic field is as evenly distributed throughout the chambers as conceivable. Short circuiting has taken place from time to time, but has invariably been the result of irregular cleaning of the grids: such difficulties will disappear as the practice becomes standardised.

The authors regard the above considerations as of the utmost importance in the successful application of electrostatic methods to cleaning blast-furnace or any other gas.

Fears have been expressed in some quarters, indeed at last year's September meeting of this Institute, that the risks of explosion were great in passing electric discharges through a combustible gas, in the event of sparking. This would certainly be the case if the gas were mixed with air so as to provide an explosive mixture. It so happens, however, that the whole system is under pressure from the furnaces, and air admixture is impossible unless minus pressures are incurred. Against the latter eventuality there has been provided an automatic switch which cuts off the discharge in the event of dangerous minus pressures. Under no circumstances has an explosive condition been approached in the main system, although care must be exercised when "bleeding out" individual chambers (*i.e.*, replacing gas by air for cleaning purposes) to cut off the electric discharge. Through neglect of this precaution a few weak explosions have occurred, which, however, were perfectly harmless.

Lay-Out and Construction.

The construction of the plant has been dealt with very fully by Mr. Arnold Bury, engineer-in-charge, in a further section of this paper, but the following points require special emphasis:—

In laying out the electrostatic installation regard had to be had to the fact that a new and unknown factor was being introduced into the gas system upon which the whole of the works (blast furnaces, steel works, coke ovens and power-house) was dependent. It was decided, therefore, to attach this plant to a by-pass flue in order that it might be possible to revert to the old dirty gas supply in the event of trouble, pending the standardisation of the new practice. It has only been necessary to by-pass the electrostatic plant on one occasion; that was when making improvements to the dust-removal gear. Nevertheless it is strongly recommended that the electrostatic system should be placed on a by-pass flue, especially where all sections of the works are interdependent, as at Skinningrove. To make this policy complete, flues and pipe connections have been built so that stoves, boilers and power gas-washing plant can be supplied instantly either with electrostatically-cleaned gas or dirty gas.

As indicated above, the electrostatic plant itself is divided into 16 cleaning units, each with two discharge grids placed in series. This multiplicity of chambers was adopted, as already stated, to ensure maximum contact between the electrostatic discharge and the gas to be cleaned, by splitting up the gas flow into multiple streams; also to avoid passing large quantities of dirty gas into the system when cleaning the chambers (during which operation the discharge must be cut off), which would have been the case if a smaller number of larger chambers had been employed. The same remarks apply to chambers off for electrical repair or alterations.

The 32 transformer sets are placed in a building immediately above the cleaning chambers, so as to shorten the lead of high tension cable conveying the uni-directional current to the discharge grids in the cleaning chambers, thereby reducing the amount of electrical leakage to a minimum. By this disposition of electrical plant the current consumption has been kept down to 50 kw. for treating the entire make of gas from 3,000 tons pig-iron per week.

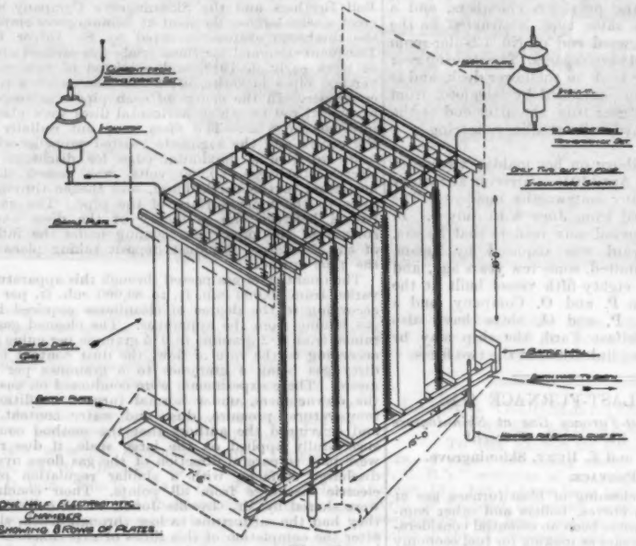


Fig. 1.

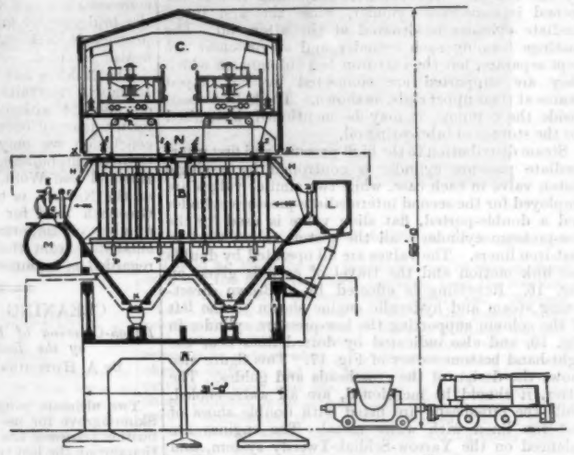


Fig. 2. Sectional Elevation of Plant.

Each cleaning chamber is provided with two cleaning hoppers, situated under their respective discharge grids. Each grid is provided with rapper gear, operated by levers, which during the cleaning operations shakes the discharge plates and precipitates the dust into the hoppers, whence it is removed by scraper conveyors to the potash extraction plant. The operation of cleaning each chamber takes place every 8 hours, for which purpose the gas and current are cut off, the discharge plates rapped, and the dust withdrawn from the hoppers to the conveyors. Fig. 1 shows one-half of a cleaning chamber.

The potash extraction plant, which is described fully in a further section of this paper by Mr. Olle Ollander, chemical works manager, and Mr. Frank Bainbridge, chief chemist, consists of mixers for lixiviating the soluble salts from the dust (chlorides of potassium, sodium, calcium), revolving filters for separating the insoluble matter from the solution of chlorides (designed by Mr. Ollander), and two Kestner evaporators.

(*a*) Removing by fractional crystallisation the potassium and sodium chlorides from the calcium chloride.

(*b*) Separating by fractional crystallisation the potassium and sodium chlorides.

The erection of the plant was commenced during the latter period of the war, when constructional steel was practically unobtainable. On this account the authors were forced to construct the gas chambers, gas mains, transformer and potash buildings of ferro-concrete. In the beginning they had doubts as to the ability of ferro-concrete to stand temperatures up to 250 deg. C.; but having submitted slabs of ferro-concrete of the composition it was proposed to employ to similar temperatures over considerable periods of time without ill effect, it was decided to adopt this material in the construction throughout. The authors are gratified to state that the work has withstood these temperatures without leakage and with a minimum of cracking. They would not now hesitate to employ ferro-concrete for similar work at temperatures ranging to 300 deg. C. The design of the ferro-concrete construction was in the hands of the Simon-Carves Company, of Manchester, and the authors have especially to thank Mr. J. H. Brown, joint managing director, and Mr. John Elcoate, of Middlesbrough, for the excellence of their work and the manner in which their contract was fulfilled.

Construction.

The building, which is 128 ft. long, 31 ft. wide, and 65 ft. high, consists of three entirely distinct ferro-concrete structures, viz.:—

(*a*) A bridge over the slag loco. tunnel, giving a head room above rails of 13 ft. 8 in. On the deck of this bridge are two scraper conveyors for moving the dust from the 32 hopper valves to the storage and mixing tanks, situated under the far end of the bridge. Resting on the web girders of this bridge, but not structurally attached to it, are the dust depositing chambers, B, allowance for their independent expansion under the influence of the hot gases being made by means of cast-iron sliding shoes and seats at *x x* (Fig. 2).

The chambers, 16 in number, are each 31 ft. long, 7 ft. 6 in. wide, and 23 ft. high from the hopper mouth to roof. Baffle plates at the top and bottom of either end restrict, however, the available height for the passage of the gas to 10 ft. 6 in. Each chamber is provided with an inlet valve D, 3 ft. in diameter, and a double outlet valve E, composed of a set of sliding grids F for regulating the amount of gas passing the chamber, and a mushroom valve G, direct on the clean gas main.

There are four explosion doors at either end H, a manhole with explosion door in the roof J, and a dust discharge valve K in each of the two dust bins with which each chamber is provided. These bins have a capacity of about three-quarters of a ton of dust. The hot dirty gas passes to the chambers from the old underground dirty main by a vertical circular ferro-concrete stand pipe, 6 ft. 6 in. in diameter, and thence by a horizontal main L, rectangular in section, to the chambers. This main is provided with hoppers and dust shoots, leading down to the gangway, opposite the end of each chamber, so that it can be cleaned of dust, without interrupting the operation of the plant. It is built in six sections with telescopic joints to allow for expansion, and is carried on cantilevers, on some of which it is free to slide during expansion.

The cleaned gas leaves the chambers by a circular main M, with similar provision for expansion.

Above the chambers is the insulator floor N, carrying the insulators S, which transfer the current from the Lodge high-voltage transformers O in the transformer house C. The hammer gear for vibrating the plate electrodes in the chambers is shown at P and R. Each chamber is furnished with two electrical units, each consisting of a transforming set, in the transformer house and a set of plate electrodes, 85 in number.

At the time the plant was projected it was almost impossible to obtain plates, and it was decided to use ferro-concrete for the structure, a further advantage being that there would be much less radiation than with steel plates. In view of the high temperature in the chambers, rising at times to the neighbourhood of 300 deg. C., which would occasion heavy stresses, exceptional care was taken in the design and construction of the ferro-concrete. As an example of this the partition walls between the chambers contain four times as much steel as an ordinary ferro-concrete wall double the thickness. The concrete consisted of one part best cement, 10 per cent. of its weight of slaked lime, two parts of sharp sand, and two parts of hard burnt red bricks or old coke-oven brick.

On the start-up of the plant the expansion of the building was carefully observed, and during the first day did not exceed more than a quarter of an inch, from the centre to each end. (The three structures are looked on the centre line, between chambers Nos. 7 and 8.) Since then further expansion to the extent of one-eighth of an inch has taken place, and the limit seems to have now been reached.

During the course of the first day several cracks appeared, mainly in the region where the hot dirty gas enters the plant. Since then other cracks have developed, but in every case they are symmetrically disposed, and it was satisfactory to note that during

the short shut-down at Whit-week almost the whole of the cracks closed up to such an extent as to be practically invisible. In constructing similar chambers again such cracks could probably be entirely obviated by dividing the steel reinforcement, placing half near the outer surface of the concrete, and the other half near the inner surface. A contributory cause of the cracking is that the sliding shoes are of too stiff a type, and an improvement could readily be made here.

As a matter of precaution tie rods have been placed above the roof of the chambers and between the column tops.

Extraction of Potash from Deposited Flue Dust.

Theoretical Considerations.—The soluble constituents of the flue dust obtained from the electrostatic plant at Skinningrove Ironworks are almost entirely in the form of chlorides, only very minute traces of sulphate being present and carbonate and cyanide not at all. The average analysis is as follows :—

	Per Cent.
Soluble potassium chloride	20·0*
Soluble sodium chloride	8·0
Soluble calcium chloride	7·0

On this account the separation of pure potassium chloride presented few difficulties.

The method of separation finally decided upon is divided into two stages :—

1. Separation of the sodium and potassium chloride from the calcium chloride as a mixed salt.
2. Separation of the potassium chloride from the sodium chloride.

The first stage is accomplished by direct evaporation, and is rendered possible by reason of the extreme solubility of calcium chloride as compared with the solubility

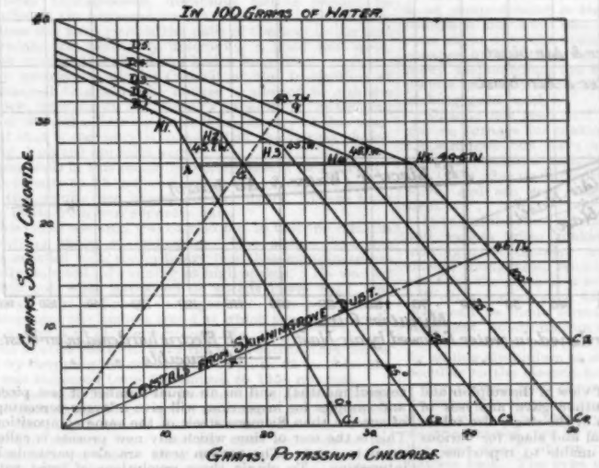


Fig. 3. Solubility Curves of K and Na Chlorides.

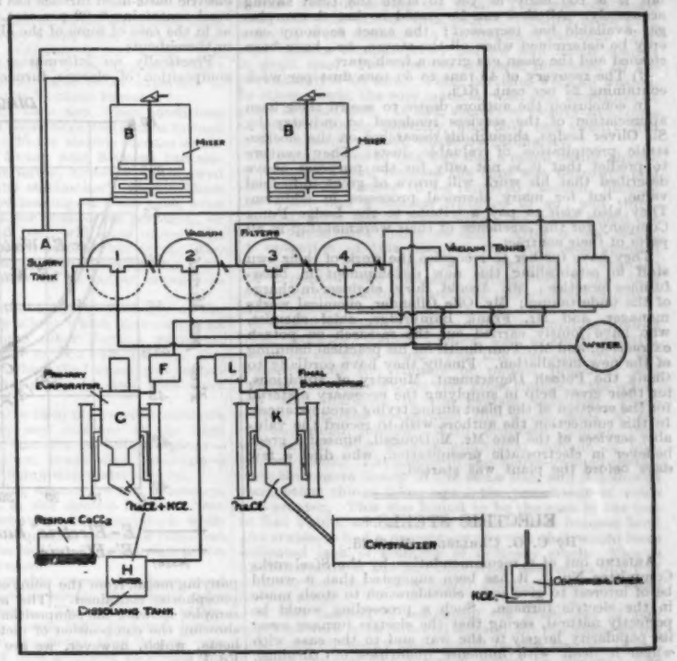


Fig. 4. Potash Recovery Plant.

of sodium and potassium chloride, 31·7 kg. of calcium chloride requiring rather less than 49·1 kg. of water for solution. If, therefore, the "strong liquor" be evaporated to this concentration and cooled, 90 per cent. of the potassium chloride and sodium chloride will be thrown out of solution. It is possible further to reduce the KCl and NaCl content of the liquor, but as the calcium chloride may be used to remove the carbonate from alkali carbonate bearing flue dusts by double composition there is no need to endanger the purity of the mixed crystals by further concentration.

The second separation is based on a series of cooling curves constructed from the data obtained by Precht, Wittgen, Rudorff, and Nichol, as follows :—

Solubility in Grammes per 100 Grammes of Water.

Deg. C.	KCl.	NaCl.
0	11·2	30·0
25	15·8	29·0
50	22·0	27·7
70	27·3	26·8
80	30·0	26·4
100	34·7	25·8

—from which it will be seen that the solubility of potassium chloride increases with the temperature while the solubility of the sodium chloride decreases. The saturation points from 0 deg. to 100 deg. C. are shown in the equilibrium curves diagram (Fig. 3).

In this diagram the weight of NaCl in the solution per 100 parts of water is measured along the vertical axis, and that of KCl along the horizontal axis. The points D1, D2, D3, D4 and D5, represent the composition of solutions saturated with NaCl at 0 deg., 25 deg., 50 deg., 75 deg. and 100 deg. C. respectively ; the points C1, C2, C3, C4 and C5, that of solutions saturated with KCl ; and the points H1, H2, H3, H4 and H5, that of solutions saturated with both salts. The lines D1 to H1, &c., represent the composition of solutions saturated with KCl, which contain varying amounts of NaCl. It is assumed that all these lines are straight, and although no actual measurements have been made it is probable that they are curves which differ but slightly from straight lines.*

An extraction of Skinningrove flue dust is shown by the chain line. On evaporating this solution no crystals are deposited until a density of 46 deg. Twaddel is obtained. This is shown on the diagram by the intersection of line X and H5C5 when the solution is saturated with potassium chloride. If evaporation be now continued potassium chloride crystallises out until a density of 49·5 deg. Twaddel is obtained, the composition of the solution changing as shown on the diagram by the line joining the point of intersection with H5, at which point the solution is saturated with both salts, and if the evaporation were continued a mixed salt would be thrown out. At this point, however, the solution is cooled and potassium chloride crystallises out according to the horizontal line H5 G, which, it will be seen, cuts all the saturated lines at points which show a saturation for potassium chloride but not for sodium chloride, finally reaching the point G on the 250 deg. C. line, which is the lowest temperature in actual practice. On reheating the solution no crystals are obtained until the point q is reached, at which point the solution is saturated with sodium chloride but not with potassium chloride. Evaporating further, sodium chloride will be deposited according to the line *q* H5, and if the solution be filtered hot to remove the sodium chloride, potassium chloride again crystallises out on cooling, the operations now becoming a cycle, in which, whenever the points G, q, or H5 respectively are reached, the composition of the solution is the same as at the same point in the preceding cycle, the bulk only being reduced.

Extraction of Potash from Deposited Flue Dust.

The dry dust from the conveyor is lixiviated with water or wash liquor as it falls from the conveyor chute into the concrete slurry tanks A (Fig. 4) below the electrostatic plant. In order to prevent any settling this slurry is circulated continuously through the chute, thus producing an intimate mixture, only enough water or liquor being added to produce a slurry thin enough to be pumped through the circulating system and to the mixers B. In the mixers, which are steel vessels of about 800 gallons capacity and provided with efficient stirring arrangements, the slurry is boiled and then continuously run down on to a series of revolving vacuum filter drums 1, 2, 3 and 4, situated below the mixer. The filter drums, which are 3 ft. 6 in. diameter and 7 ft. 6 in. long, are built of oak laths, 3 in. apart, covered with a strong wire net, which carries the filter cloth. To protect the cloth a ¼-in. steel wire is spirally wound round the drums, which are driven by a worm gear, and revolve at 2 r.p.m. The wells in which the drums revolve are built in concrete with a cast-iron front, and in order to prevent any settling they are made V-shaped, with a stirrer revolving along the bottom. The dried cake containing about 30 per cent. moisture is cut off by a steel knife placed in such a position that the cake flaked off from one drum falls into the well of the next, where it is each time boiled with a weaker liquor. By having four drums four consecutive washings with liquor of falling strength are obtained, the last washing being done with water ; and the last cake, free from soluble salts, is transferred by a worm conveyor to railway trucks outside the building, whence it is returned to the blast furnaces. The liquors from the four drums are drawn off by vacuum into separate suction tanks and from there delivered intermittently to the respective storage tanks. The strongest liquor, of about 32 deg. Twaddel, from No. 1 drum, is filtered through a sand filter and then delivered to the preliminary evaporator. The liquor from No. 2 drum goes to the slurry tanks, the liquor from No. 3 drum is used for washing in No. 2, and from No 4 drum for washing in No. 3, and No. 4 receives water.

Evaporation and Crystallisation containing KCl, NaCl and CaCl.—The strong liquor of about 32 deg. Twaddel is transferred to the feed tank F for the preliminary evaporator, where it is heated by indirect steam and then continuously fed into a Kestner salting type evaporator G, in which the separation of the sodium and potassium chloride from the calcium chloride takes place. The crystallisation starts at about 62 deg. Twaddel and continues to about 94 deg. Twaddel, and the salt is periodically drawn off on to a vacuum filter, where it is washed once with liquor from No. 2 evaporator in order to free it from any mother liquor containing calcium chloride. When the saturation point of the three salts is reached, which occurs at about 94 deg. Twaddel, the evaporator is emptied and the cycle started again. The residual liquor is evaporated to dryness in open pans heated by bunsen fire.

Preparation of Potassium Chloride from Mixed Salt.—The mixed crystals are dissolved in hot distilled water or liquor from the final evaporator K in tank H, from which they pass through a filter and then into the feed tank L, and finally into the evaporator K. Evaporation is then commenced and continued until the liquor has a density of 49 deg. Twaddel. During this evaporation potassium chloride crystallises out and more liquor is added until the evaporator is completely full of liquor of the required density, at which point the whole contents of the evaporator are run out and passed through a revolving crystalliser, more potassium chloride being deposited during the cooling. The mother liquor is drained from the crystals in a centrifugal hydro-extractor and returned to the feed tank L, from which it can either be supplied to the crystal dissolver H or to the evaporator K for further evaporation. In the latter case the liquor is evaporated until the density again reaches 49 deg. Twaddel, but owing to the saturation of the liquor only sodium chloride is thrown out of solution during this second evaporation, as explained in the theory of the process. The sodium chloride is removed from the evaporator by means of the vacuum filter box, and the clear liquor run through the crystalliser, when potassium chloride again crystallises out. From this point the process is cyclic, sodium chloride crystallising out on evaporation and potassium chloride on cooling. It is obvious, of course, that the above operations may be varied, and modifications are made from time to time in order that the final evaporator may be kept full of concentrated liquor.

Summary.

The plant has only been at work since April 8 last—that is, approximately four months—and the authors could have wished for a greater period of time before communicating their results to this Institute, as the plant has not had time finally to be tuned up. In view, however, of their promise to read a paper at this meeting

* More recent analyses of dust taken from the full-scale plant show a considerably higher percentage of potassium chloride than this.

* See Blasdale, *Journal of Industry and Engineering Chemistry.*

of the Institute, coupled with the present keen interest universally displayed in gas cleaning, they submit their results so far as they have been obtained, with the promise of adding their further experience when acquired.

In the meantime they are content to have so far proved the following points with regard to electrostatic rough gas cleaning at Skinningrove :—

(a) That with 80 per cent. to 85 per cent. of the electrostatic plant at work (remainder awaiting electrical equipment), the dust in the gas has been reduced from 5 grammes to 6 grammes per cubic metre in the dirty gas, to 0·8 gramme to 1·1 gramme in the cleaned gas ; or, in other words, to the standard of Continental practice for stove and boiler use.

(b) That the above result has been attained with a total fuel consumption corresponding with 50 kw. only.

(c) That no power is necessary for pumping water or for moving gas through the system.

(d) That the cleaning has been effected by a comparatively small loss of the original sensible heat. The raw gas enters the cleaning chambers at 220 deg. to 250 deg. C and the cleaned gas leaves at 200 deg. to 220 deg. C.

(e) Less gas is being used at the stoves and boilers, but it is too early as yet to state the total saving accurately. All that can be stated is that the surplus gas available has increased ; the exact economy can only be determined when all the stoves, &c., have been cleaned and the clean gas given a fresh start.

(f) The recovery of 48 tons to 50 tons dust per week containing 27 per cent. KCl.

In conclusion the authors desire to record their keen appreciation of the services rendered to industry by Sir Oliver Lodge, through his researches on the electrostatic precipitation of valuable dusts. They venture to predict that it is not only for the purposes above described that his work will prove of great industrial value, but for many chemical processes in addition. They also wish to pay a tribute to the Lodge Fume Company for the excellence of their workmanship in all parts of their contract.

They have further to recognise the work of their own staff in establishing this new development in blast-furnace practice ; Mr. Arnold Bury, engineer-in-charge of the undertaking ; Mr. Olle Ollander, chemical works manager, and Mr. Frank Bainbridge, chief chemist, who have jointly carried out the research on potash extraction, and Mr. Tom Smith for his practical handling of the new installation. Finally they have cordially to thank the Potash Department, Ministry of Munitions, for their great help in supplying the necessary material for the erection of the plant during trying circumstances. In this connection the authors wish to record the valuable services of the late Mr. McDougall, himself a great believer in electrostatic precipitation, who died a few days before the plant was started.

ELECTRIC STEELS.*

By C. G. Carlile, Sheffield.

Arising out of a recommendation by the Steelworks Committee No. 3, it has been suggested that it would be of interest to give some consideration to steels made in the electric furnace. Such a proceeding would be perfectly natural, seeing that the electric furnace owed its popularity largely to the war and to the ease with which it dealt with immense quantities of turnings, rather than to any real conversion on the part of steel manufacturers (with some notable exceptions) in their opinion as to its merits.

Looking back to the days of 1905, when Dr. Hutton lectured in Manchester on electric furnaces to an enthusiastic small audience, the Sheffield contingent being no larger than a single railway compartment would hold, the author contrasts the reception accorded to the meeting held in Manchester in 1918 by the Faraday Society with a collection of papers on the same subject. By that time interest in the subject had increased tenfold, simply because the electric furnace had ceased to be an experimental apparatus in the hands of dreamers and patentees, and had made an immense stride, the electric furnacemen having become very serious contributors to the output of steel of the best quality for war purposes.

Viewing this development in its broadest aspect and as impartially as possible, and giving every possible credit to inventors and their collaborators for their perseverence in perfecting a tool possessed of such tremendous possibilities, in the face of all manner of difficulties in construction and design, it may, nevertheless, be claimed that, however well thought out, final success would not have been achieved so quickly, or at all, had not another section of humbler workers, mostly from the metallurgical side, and freer from prejudice or interest, taken the furnace under control and eliminated the difficulties one by one.

In the main, if success is to be achieved, it depends not only on a knowledge of metals and of chemical and physical reactions, but on the moral qualities of the worker, combined with an alertness of mind capable of observing the phenomena associated with success and failure.

It is the degree of persistency and patience shown in evolving those factors necessary for a successful heat, when conditions are all adverse, that differentiates the good from the bad worker. It is largely due to this psychological fact that so much failure has been experienced with electric furnaces and so much poor steel made. Speaking from experience, the author would claim that the making of good electric steel is directly proportionate to patience rather than to knowledge.

There has been a surfeit of talk about production as a cure-all ; no better illustration of the wrong interpretation of this magic word could be found than the farcical method of running the electric furnace by the clock and specifying beforehand the length of time that must be taken per heat. The most amusing experience was of the worker who set himself to get a heat out of a 3-ton furnace in 4½ hours, and became greatly excited if 4½ hours were taken, sometimes managing to get it out as the clock struck the quarter, to be rewarded, in consequence, with spongy ingots. In this connection the author cannot refrain from laying much blame on the patentees, in their zeal for business, for stressing this point of time, nor excuse the gullibility of the buyer for thinking that he had bought an automatic machine for making steel. The engineer's specification that in effect says that "no electric steel need tender," is not an indictment of electric steel in itself, but of those plant owners who have shown a lack of appreciation of the factors referred to above as necessary for success.

The history of steel-making during the last thirty years could be written in terms of a struggle to keep sulphur and phosphorus down. The acid Siemens process was a distinct advance on the Bessemer, and the basic processes made a still further step ; but the electric basic-lined furnace has made it possible to obtain steel containing 0·02 per cent. sulphur, and sometimes as in the case of some of the alloy steels, 0·01 per cent., or thereabouts.

Practically no information is available as to the composition of electric furnace slags and the accompanying metal, from the point of view of the sulphur and phosphorus contained. (The author gave analyses of samples showing the composition of the slags, also tables showing the composition of metal and slags for various heats, which, however, we are unable to reproduce.—Ed. E.)

According to Dr. Geilenkirchen, in his paper on "The Removal of Sulphur in the Héroult Process "* : "The one condition is that the slag must be free from metal oxides before sulphur in any considerable degree can be transferred from metal to slag ; there is less chemical work in reducing oxides than sulphides, therefore the one follows the other. To prevent oxidation of CaS to $CaSO_4$, which is liable to be thrown back into the metal again, it ($CaSO_4 + 4Fe = FeS + 3FeO + CaO$) requires a reducing agent. The change of FeS and MnS into CaS can only take place in presence of a powerful reducing agent, $2CaO + 2FeS + 2C = 2CaS + Fe_2 + 2CO$. In the basic Siemens this happens in the refining process with the reduction of the carbon in the metal and then only on the surface near the slag."

Calcium carbide is claimed by him as the chief reducing agent :—

$$3FeO + CaC_2 = 3Fe + CaO + 2CO \quad (1)$$
$$2CaO + 3FeS + CaC_2 = 3CaS + 3Fe + 2CO \quad (2)$$

When this oxidation takes place and no more oxides are left in the bath, the sulphur is taken out of the bath into the slag.

The figures obtained confirm in the main the above contentions.

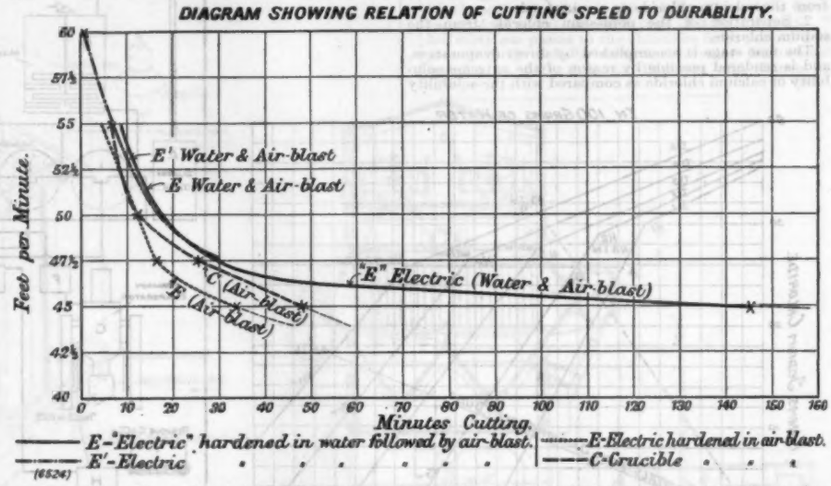
Size of furnace evidently has an important effect on the elimination of sulphur. This is due mainly to the fact that the oxidising slag can be raked off with greater minuteness in the small size of furnace, but it is also due to a larger slag area in proportion to weight of bath. Phosphorus cannot be reduced in like degree, due to some extent to the greater care needed in adding ore, as the cutting action on the banks is slightly greater owing to the greater length of slag line per unit weight of metal.

It is for the most part the ability and art of the furnaceman in controlling his slags so as to obtain liquidity and correct thickness over the whole area of the bath throughout the charge, and more especially during the refining period, that determines whether sound metal is produced or not. In no other steel process does the slag play such a fatal part, or call for such wariness from the furnaceman. Five or ten minutes neglect of the slag, and the metal often will be converted from sound to unsound material, as it becomes uncovered owing to the slag losing fusibility.

The interplay between current and reagent, and whether to increase or reduce the amperage of the first, or which of several materials composing a slag to add in any contingency arising, become matters of intuition on the part of the operator, as well as calling on all his resource. The method of manufacture can, however, only be of absorbing interest to those few directly engaged, and those few generally prefer to work out their own plans of salvation.

What is required is the amount of confidence to be placed in the final product—the steel itself. Brought largely into being during the early period of the war, to augment supplies of munition steels, the process escaped that close scrutiny of cost which at an earlier period, and in peace, it would have been subjected to. The touchstone was quality of product ; the consideration of price, though not overlooked, was of secondary importance. This was the opportunity, and having this singleness of aim the electric furnacemen rose to the occasion, and in a marvellously short time were producing, in competition with the Siemens furnacemen, the finest steels, suitable for making gun steels, bullet-proof steels, and aeroplane steels, when that industry made such large demands upon the resources of steel-makers. (Particulars of tests of electric steels made to Air Board specifications are given by the author.) Tests show that the electric furnace is capable of making excellent nickel-chrome steels. It can further be claimed as a matter of past experience that electric nickel-chrome steels, during any given period (say several months), and on an equal number of test pieces and samples for inspection, will give a larger percentage of success than Siemens steels of the same composition. This is the test of time which any new process is called upon to meet. The torsion tests are also particularly interesting. To obtain three revolutions of twist with a tensile of 67 tons, denotes density and sound material. Compression tests would have shown up still more clearly the value of the series.

DIAGRAM SHOWING RELATION OF CUTTING SPEED TO DURABILITY.



Tests show that the electric furnace is capable of making excellent nickel-chrome steels. It can further be claimed as a matter of past experience that electric nickel-chrome steels, during any given period (say several months), and on an equal number of test pieces and samples for inspection, will give a larger percentage of success than Siemens steels of the same composition. This is the test of time which any new process is called upon to meet. The torsion tests are also particularly interesting. To obtain three revolutions of twist with a tensile of 67 tons, denotes density and sound material. Compression tests would have shown up still more clearly the value of the series.

The main points of interest in the author's tests are :—

1. The high yield-point of one sample, viz., 120 tons ; as high as the best results in high-speed steel, but giving a smaller amount of set, viz., 0·010 in. against 0·024 in in the latter steel.

2. The load was applied quickly in order to find out if the steel would resist shock without breakdown, and to what extent the set would be affected. Contrary to expectation, no appreciable difference was obtained in the set only (0·003 in. in one sample, 0·001 in. in another), and the samples were free from cracks altogether, whilst in the first of these two samples the Brinell number was equivalent to that of an engineer's tap ready for use.

A practical application of this steel was made over two years ago when the demand for high-quality tungsten steel aeroplane exhaust valves was at its maximum ; stamping dies, made from this nickel-chrome steel and used for embossing the valve, were watched for a time. A pair of dies, used alternately, stamped 24,000 valves without requiring machining. Further records were not taken, but as these dies are still in use, it is estimated that 60,000 to 70,000 valves must have been stamped in them, with only a few machinings to re-surface the die. Slight breakdown of surface ensues after prolonged use, mostly due to the practice of quenching in water, after stamping say two or three valves. The compression test results are borne out, therefore, by workshop practice, over a long period.

Another series of compression tests, also tabulated in the paper, are interesting from several points of view.

1. High tungsten steels give a high yield-point and generally avoid breakdown up to 180 tons to 190 tons.

2. Salt bath heating, prior to hardening, increases the power of resistance, giving less set ; final collapse at 200 tons pressure is also avoided.

3. No difference in set is obtained with load applied in the direction of rolling or applied at right angles to it.

4. With gas furnace heating of samples, the electric steel remains sound with 200 tons pressure, whereas the crucible steel crushes with loads of 190 tons and 199 tons respectively.

* Abstract of a paper read before the Iron and Steel Institute at Cardiff, September 22, 1920.

* *Stahl und Eisen*, June 17, 1908.

5. The mean yield-point of the crucible steel is 105 tons, of the electric, 112·5 tons.

6. When hardened from 910 deg. to 960 deg. C. the point of breakdown is fairly constant.

High tungsten steels are useful in certain classes of cold stamping where great density is required in the die. Through the kindness of Dr. Hutton and Mr. Hanson, a die has been made from electric high-speed steel and put into use for dessert spoon spreading; so far some 30,000 spoons have been dealt with, the die still being in use and in good order. Generally speaking, a die capable of going so far continues giving a much longer life.

Before leaving the subject of dies a few further tests may be of interest. Two steels were selected for trial, for the difficult work of tube drawing, difficult in respect of obtaining a die steel to give a sufficiently long life, before re-machining.

Mr. Reilly (of Muntz Metal Company), to whom the author is indebted for his careful record of the performance of these steels, supplies the following particulars:

Crucible steel No. 9. Die drew 828 tubes. Best die hitherto tried, maximum of 500 tubes.

Electric steel No. 113. Die drew 325 tubes. Best die hitherto tried, gave a maximum of 200 tubes, as a harder quality of tube was drawn in this case.

The problem of die steels is very complex, as the purposes for which they are required are multitudinous, but the author has shown that wear, shock, compression, rigidity of shape, have all been satisfied by using electric steels of various qualities.

It would be as well now to examine the cutting power of electric steels; the author has devoted a good deal of time to this important subject, but the factors and processes involved are so many that it is exceedingly difficult sometimes to form a judgment. As cutting involves another steel to be cut, and since this may be far from homogeneous, durability testing cannot be regarded in the same manner as tensile testing. It only requires one hard spot in the path of the tool under test to vitiate the result, by destroying a good tool nose, which would otherwise have had a long life.

By permission of the Council of the Institution of Mechanical Engineers the author is allowed to cite the remarks he made on Mr. Burley's paper on "The Cutting Power of Lathe Turning Tools" in January of this year.

All that is necessary is to republish the curves shown in Fig. 1 on the opposite page.

Four tools in this series (two crucible and two electric), 16 per cent. to 18 per cent. tungsten type, were taken, and the results are shown in the figure. These tools were made from four separate bars.

This small research was carried out to find the relation of cutting speed to endurance. The author had not been satisfied with the ordinary test that manufacturers usually adopted, of running at high speeds. He wanted to find out what happened at speeds lower than, but yet well over ordinary shop practice, and particularly to determine the highest speed at which the curve would flatten out, *i.e.*, give a very long life.

The electric steel tool gave the most satisfactory curve, and by dropping the speed from 55 ft. to 45 ft. only, the life was increased from 8½ minutes to 145½ minutes.

The bar used for the test was hard steel, carbon 70 per cent., manganese 77 per cent., normalised (not annealed, as is generally adopted) with a Brinell hardness of 255. This 145 minutes' test was the most remarkable the author had yet seen. After 100 minutes had elapsed, the tool and the chips began to show redness which continued until exhaustion occurred. The crucible steel used gave inferior results with water-hardening as compared with air-blast hardening, so further tests at lower speeds were not considered worth doing. The standard tool of a well-known water-hardening steel was inferior at 55 ft., and at 50 ft. very erratic.

It is not intended to try the crucible variety, but inadvertently some drills of crucible steel crept in and after testing were differentiated later by means of analysis, the amount of sulphur giving an easy means of separation. A further series of drills of the milled pattern have lately been tested, in order to check the first series, especially to see if the 400-in. record (total depth of cut in inches), was a freak result or not.

The remarkable fact which proceeds from the author's tests is that the electric steel again survives the ordeal of drilling 200 holes of 2 in. in depth, leaving a tool capable from all appearance of doing considerably more work, whereas the author has never yet obtained a crucible drill which will do the same.

On the other hand, there is a remarkable recovery of cutting power, after tempering at 550 deg. to 650 deg. C., which is not met with in the electric steel; but this point does not seem to have any practical significance.

Dealing with the demand for an improved aeroplane exhaust valve steel, the author submitted to Dr. Aitchison some samples which he anticipated might combine the advantages of the high tungsten quality with regard to strength at high temperatures and also approach the low corrodibility of the high chromium steels.

The following is an extract from his report:—

"The steel was tested in tension at temperatures of 700 deg., 800 deg., and 900 deg. C., and gave the following results:—

Temperature. Deg. C.	Ultimate Strength. Tons per Sq. In.
700	19·0
800	10·27
900	11·15

The strengths possessed at the same temperatures by the usual high tungsten steel to Air Board Specification K.8, or the high chromium steel to Specification S.19, can be compared from the figures in the next column.

The mechanical properties of the new steel in the cold are very similar to those of the high tungsten steels. As regards corrosion and scaling, the new steel is rather better than the tungsten steel, but inferior to the high chromium steel.

"This steel appears to show, in a comparatively marked manner, the increase of strength which occurs in both the tungsten and the chromium steels at temperatures higher than 800 (followed, of course, finally, by a fall in strength)."

This steel was made in the electric furnace.

Much space has been devoted to a few qualities of steel where mechanical tests could be supported by usage in actual practice, or where it was possible, as in the cutting tests, to more than meet the demands made by the workshop. This is the only method that will appeal to the engineer or the general user of steel, and also will afford members of the Institute an opportunity of hearing

Steel.	Ultimate Strength. 700 deg. C.	800 deg. C.	Tons per Sq. In. 900 deg. C
New steel ...	19·0	10·27	11·15
K.8	19·0	9·5	8·9
S.19 ...	10·5	6·5	6·5

a more practical aspect (hitherto regarded as firms' secrets) than is customary.

Cost of production has been excluded altogether from the paper, as it varies in every works according to equipment, design, and space available in the shop. But suppose it is arrived at, what is it to be compared with? Are several 3-ton or 6-ton furnaces to be expected to compete with, say, six 50-ton Siemens furnaces?

From costs got out some time ago, when conditions were much steadier than in these days, the author formed the opinion that a 15-ton to 20-ton electric furnace would produce as cheaply as a 50-ton acid Siemens furnace. The question of cost must never, however, be allowed to take first position in the steelmaker's mind! There is no compromising in steel-making—a good heat, even though it may have cost 5 per cent. or 10 per cent., or even more over the second best, will have proved the cheaper by the time the steel reaches bar form. Too many technologists are engaged in investigating complaints of bad steel; they would be better engaged in making good steel.

Nothing has been said about the adaptability of the electric furnace for making alloys which approach steel for strength but have some other distinct property, such as electrical resistivity or non-corrodibility, &c., but these offer no difficulty which the furnaceman cannot solve, and are very often simpler to deal with than steel.

It is certainly not advisable to apply crucible methods and recipes when making any mixture of the high melting-point metals; no amount of killing agents—silicon, manganese, aluminium, magnesium, titanium—can take the place of a reducing slag under control.

With a correct slag, killing agents are not necessary. Steel can be made sound in the electric furnace, heat after heat, no aluminium whatever being required, while an incorrect slag and its consequences cannot be remedied by adding aluminium to the ladles. This is a distinction peculiar to the electric furnace.

For making steel castings this process has been tried for some considerable time with results which have more than satisfied the foundrymen. The possibilities of the electric furnace are by no means fully explored, but it has been clearly shown in the paper that it is a very flexible tool. The type of men available to obtain the best from it constitutes the real problem.

The steels that have been described so fully have all been made in Messrs. J. Beardshaw and Son, Limited's, electric furnace, and it is due to the magnanimity of spirit shown by Mr. Beardshaw that the author has been able to go so far in his treatment of the subject. For this he is deeply grateful. He is also indebted to Dr. Aitchison for his careful and favourable report on the valve steel, and to Dr. Hutton and Mr. Hanson for considerable care taken with die steels; also to Mr. Reilly, of the Muntz Metal Company, for similar work.

OPPOSITION TO QUESTIONNAIRES IN THE U.S.A.—The official insatiable thirst for statistics which has developed into a mania in this country and resulted in the issuance of a multiplicity of forms demanding information on every possible subject directly and indirectly connected with one's business, has its counterpart also in the United States of America. Business men over there have, at length, reached the limit of their patience, and have decided no longer to comply with these complicated statistical demands involving the waste of a vast amount of time in filling in useless forms, to say nothing of the waste of paper now so precious. The Federal Trade Commission, an exceedingly busy and energetic body, has now realised the force of the business men's opposition, and it is understood that the filling-in of questionnaires is not to be compulsory. The strongest opposition has been encountered in the iron and steel trades, and the rights of the Commission to demand information on costs of production, &c., every month have been questioned in the courts. In one of the courts it was ruled that the Commission had no such legal rights, a decision against which the Commission is appealing. The latest opposition is from the lumber industry, which threatened to institute injunction proceedings when the Commission endeavoured to inflict its innumerable statistical forms and questionnaires on that industry. A conference was held between the Commission and the lumbermen, at which it was decided that the latter should draw up a form of questionnaire for the Commission's approval. The Commission defend their action on the ground that it is taken entirely in the interests of the industry concerned.

HYDRAULIC-FILL DAMS.*

By ALLEN HAZEN, M. Am. Soc. C.E.

(Concluded from page 428.)

Increasing the Grain Size of Core Material.—The second way of increasing stability is to use core material that will consolidate more rapidly and thoroughly. There is only one way to insure this; that is to increase the grain size of the material allowed to remain in the core. With pools and water quantities actually used in the dams known to the writer, particles smaller than 0·001 mm. and perhaps up to 0·002 mm. have been wasted. Everything larger has gone into the dam.

In some cases, an effort has been made to secure completeness of deposition of these fine particles to avoid waste and to increase the yardage accounted for in the dam.

To increase the effective size of core material, it is necessary to increase the limit of size of particles to be wasted. This can be done by narrowing the pool or by increasing the quantity of water passing it (see Figs. 3, 8, 9, and 10). On one occasion at San Pablo, to test this out, the toes were allowed to increase in height for a time without raising the pool. This was continued until the pool almost disappeared. Hardly more than a muddy creek remained in the middle of the dam. The core became comparatively narrow and much coarser in grain size. The effective size was increased to approximately 0·01 mm. Finer particles were all wasted. In other words, the core material was, say, five times as great in grain size. It had, therefore, twenty-five times as great draining capacity, and only one twenty-fifth of the capacity to hold water by capillarity.

Material placed in this way had a much better chance of drainage; first, because the core was narrower and there was less water to be removed; second, because the water had a shorter distance to go; and third, because, other things being equal, the water would get away twenty-five times as fast. After a few weeks of operation in this manner, the work was stopped temporarily, which gave an opportunity to examine the deposited core material. After only a few days it became hard enough to walk on, many times more solid than ordinary core material.

In one other respect this coarse-grained puddle differed from ordinary puddle. There was a small relative range in its grain sizes. The fine particles were eliminated, and the volume of puddle produced was reduced, but there was no very great change in the quantity and character of the coarser particles. These coarser particles constituted the whole mass of the coarse-grained puddle. With ordinary puddle, they were mixed with a large additional volume of fine-grained stock. The grains in the coarse-grained puddle were thus more nearly of the same size, and it followed that, other things being equal, the percentage of voids was greater. This was bound to be the case in the test at San Pablo, and after the material had become hard and stable, it had a percentage of voids that would have indicated lack of stability in ordinary stock. This is an illustration of the fact that voids used as an index of stability can only be properly compared for the same kind of stock.

If this method of increasing the grain size of core material were to be followed throughout the construction of a dam, obviously there would be two results. First, a great deal of fine material would be wasted. The quantity would depend upon the quantity of such material in the stock used. In the natural course of events most of this would be deposited harmlessly upon the bottom of the reservoir. Second, a dam built in this way would be much more stable but theoretically not quite water-tight. There would be an appreciable amount of seepage through core material of this grain size.

The amount of seepage loss may be estimated approximately. Assuming that the laws of flow are the same as they are in the finest sand to which experiments have extended, it was estimated that at the San Pablo Dam if the whole core material could be made 0·01 mm. and if the rest of the dam had contributed nothing to tightness, the theoretical rate of seepage would be 280,000 gallons per day. The loss of this quantity of water would not be a serious drain upon the supply, if it adds to stability. Practically, as is known from filter experience, considering the core material as a filter, it would soon silt up and become water-tight.

As a practical proposition in dam construction, core material having a grain size of 0·01 mm. is to be accepted as sufficiently fine from the standpoint of water-tightness. This size of 0·01 mm. is not given as a precise limit. It may be that still coarser material would give sufficient tightness or that finer material would drain sufficiently. The size is mentioned because it is the size of material that it was actually found possible to produce at the San Pablo Dam by reducing the size of the pool to a minimum, and because other considerations suggest that it may be suitable.

The question remains as to whether a dam in which the pool and water quantities were so adjusted as to hold the effective size of core material at 0·01 mm., or at some other selected limit, and in which the core material was never permitted to become very wide, would consolidate itself as the dam increased in height to an extent that would eliminate lateral pressure of core material.

It is the writer's idea, that a dam built in this way would certainly be more stable and safer than one in which the core material contained an additional quantity of finer particles.

This thought is similar to an idea expressed by D. C.

---

* Paper read before the American Society of Civil Engineers.

Henny, M.Am.Soc.C.E., who stated:* "Probably the nearest approach to a perfect core of great thickness which can be hydraulicked, is one composed of fine sandy silt, such as is generally found in the arid West, having little cohesiveness, good self-drainage qualities, becoming hard and solid after a short time, and yet being, if not perfectly, at least practically water-tight."

Mr. Henny's description may be taken as an accurate description of the writer's idea of 0·01-mm. material. It certainly does not apply to 0·002-mm. material. Mr. Henny's other propositions in regard to fine core material such as is ordinarily used, are believed to be well founded.

The Use of Rock Fill.—In building hydraulic-fill dams, the débris above the solid rock has been most easily worked and extensively used. Such débris is frequently fine in grain size, and its use may result in an excess of core material and a deficiency of toe material. To correct this tendency, rock fill has been added to the toe of a number of dams.

The rock fill has usually been placed as dry fill; that is to say, by blasting, steam shovel, and cars or carts. The cars or carts run on the toes of the dam and deposit material at the same time that the hydraulic process is being used to fill the interior.

At the San Pablo Dam (see Figs. 11 and 12), a similar result has been reached by handling the rock after blasting by the hydraulic method. Open flumes were used with a flow of from 15 to 20 cub. ft. per second. A 6 per cent. slope was necessary as long as wooden flume bottoms were used. With steel flumes, equally favourable results were obtained with a 4 per cent. slope. About 3,000 cub. yd. per day were placed, on an average. Pieces of broken rock up to 1 cub. ft. in size were handled under these conditions. By blasting the hardest rock available, it was possible to get material for fill that contained relatively few fine particles, and all of the small quantity of very fine material was wasted. Large additions to the toes of the dam were made in this way.

Working a quarry with a high face, it was possible to throw down great quantities of material in one large blast, and to wash many thousands of yards into the dam from a single position of monitors and flumes. The economy resulting from operating so long in one place, as compared with moving the equipment all over the hillside to pick up scattered and relatively thin deposit of débris above the rock, turned out to be fully equal to the additional cost of rock excavation; and rock fills, built in this way, cost no more per cubic yard than fill made from débris.

On the other hand, the fill made in this way is believed to be heavier, and to have a higher coefficient of friction which gives it additional value as toe material. The practical methods of handling rock fill were worked out by Mr. Hawley and D. W. Albert, Assoc. M. Am.Soc.C.E.

Quicksand Conditions in Dams.—When a granular material has its pores completely filled with water and is under pressure, two conditions may be recognised. In the first or normal case, the whole of the pressure is communicated through the material from particle to particle by the bearings of the edges and points of the particles on each other. The water in the pores is under no pressure that interferes with this bearing. Under such conditions, the frictional resistance of the material against sliding on itself may be assumed to be the same, or nearly the same, as it would be if the pores were not filled with water. In the second case, the water in the pores of the material is under pressure. The pressure of the water on the particles tends to hold them apart; and part of the pressure is transmitted through the water. To whatever extent this happens, the pressure transmitted by the edges and points of the particles is reduced. As water pressure is increased, the pressure on the edges is reduced and the friction resistance of the material becomes less. If the pressure of the water in the pores is great enough to carry all the load, it will have the effect of holding the particles apart and of producing a condition that is practically equivalent to that of quicksand.

An extra pressure in the water in the pores of such a material may be prolonged by a sudden blow or shock which tends to compress the solid material by crushing the edges and points where they bear, or by causing a re-arrangement of particles with smaller voids. An illustration of this can be seen in the sand on the seashore. Such sand, comparable to dune sand in size, is usually found to be saturated with water for a certain distance above the water level. This condition is maintained by capillarity. If a weight is slowly placed on this saturated sand, there is a slight settlement, the grains of sand coming to firmer bearings and the weight is carried. A sharp blow, as with the foot, however, liquefies a certain volume and makes quicksand. The condition of quicksand lasts for only a few seconds until the surplus water can find its way out. When this happens the grains again come to solid bearings and stability is restored. During the few seconds after the sand is struck, however, it is almost liquid, and is capable of moving or flowing or of transmitting pressure in the same measure as a liquid.

Fine-grained sand in which this condition exists is called quicksand. The properties of quicksand are well known. Fine-grained sand saturated with water and then mixed with an additional 5 per cent. of water acts practically as a liquid. It will flow through small orifices or in a pipe at a 5 per cent. slope. The sand in a mechanical filter in process of washing is a typical case. When the sand is drained, in the filter, it forms a bed as hard as any sand bed. When subjected to a reverse current of water strong enough to slightly lift it, however, the volume is increased by perhaps 5 per cent., and it becomes liquid. An object can then be pushed through it with scarcely more resistance than would be offered by a liquid of high specific gravity.

The conditions that control the stability or lack of stability in quicksand may also control the stability or lack of stability of materials in dams.

The puddle clay core of an hydraulic-fill dam is physically like quicksand, but with particles one hundred times smaller in diameter and a million times smaller in

Fig. 8. San Pablo Dam, showing Maximum Width of Central Pool.

Fig. 9. San Pablo Dam, showing ordinary Width of Central Pool producing Core Material 0.002 Mm. in Size.

Fig. 10. San Pablo Dam, showing Central Pool greatly reduced in Width for purpose of Increasing Grain Size of Core Material.

Fig. 11. Excavating Rock at San Pablo Dam by Hydraulic Jet, after Blasting.

Fig. 12. Placing Rock Hydraulically in San Pablo Dam, Fragments up to 1 Cub. Ft. being Handled by this Method.

* Transactions, American Soc. C.E., vol. lxxiv (1911) page 82.

weight. It has the instability of quicksand in full measure and it retains it for a long time, or perhaps indefinitely.

With the coarse-grained part of an hydraulic-fill dam, that is to say, with rock toes, there may be also, at times, similar condition. Generally speaking, it would be expected that such coarse-grained materials would have sufficient drainage to let out surplus water and prevent the possibility of an excess sufficient to destroy its stability. With hard-grained materials from glacial drift of New England and the Northern States, it is hard to conceive of a lack of drainage in gravel that would permit the accumulation of an excess of water. With the softer materials of the Pacific Coast, however, the conditions may be differ nt. In the first place, these soft rocks by partial crushing under pressure produce fine material which tends to fill the remaining spaces and to reduce the drainage capacity.

On the other hand, each increment of loading applied to soft-grained material produces a certain compression and settlement; and with it a reduction in voids. This may happen to a toe of soft rock on the up-stream side of a dam against which water is being stored during construction. There is first an open condition with ample voids and ample drainage. As the dam is built higher, pressure increases; there is compression and reduction in porosity. Each additional increment of loading and compression means that a certain quantity of water representing the difference between the old voids and the new voids must be expelled. As long as the material remains sufficiently pervious to carry off this excluded water, the process of compression is harmless. The surplus water is pushed back into the reservoir and stability is retained. There may come a time, however, when the compression goes forward so rapidly that the surplus water cannot be carried off fast enough. When that point is reached (if it is reached), there will tend to be an excess of water in the interstices and that excess will transmit some of the pressure that was before carried only by the bearings of solid particles, and the frictional resistance of the material will be less, and perhaps much less, than it was before.

The thought has occurred to the writer, in looking at the material that slid in the Calaveras Dam, that something of this kind may have happened on a large scale—800,000 cub. yards of fill flowed for a brief space, and then became solid. It was, in fact, so solid that in examining it afterwards, by samples and by borings, it was difficult to see how the material could have flowed—as it certainly did flow.

It may be that after the first movement there was some readjustment of the material in the toe that resulted in producing temporarily this condition of quicksand, and that destroyed for a moment the stability of the material and facilitated the movement that took place.

This will not account for the initial movement; but the initial movement of some part of the material might result in accumulating pressure, first on one point, and then on another, successively, as the early points of concentration were liquefied and in that way a condition comparable to quicksand in a large mass of material may have been produced.

Summary. To summarise briefly the points that the writer has attempted to make and to apply them practically to dam construction:

1. It is not well to build an hydraulic-fill dam of material of which any large percentage consists of clay or of particles less than 0·01 mm. in diameter; and in general all such smaller particles may well be wasted and excluded from the dam.

2. By reducing the construction pool to a minimum, and by controlling it and the quantities of water used for sluicing, the core material may be held to a certain degree of coarseness by wasting all smaller particles. An effective size of 0·01 mm. may reasonably be sought.

3. To study by borings the actual consolidation of the material, and to adjust the construction of the upper parts of the dam to the demonstrated condition of that which lies below.

4. To make the toes large enough to resist with an ample factor of safety the whole pressure of the core material as a liquid until there is demonstration of the solidification of the core to a point where horizontal pressure is eliminated.

5. To increase the weight and solidity of toes by the use of rock fill, placed hydraulically or otherwise.

6. Stability is increased by compactness. It is worth while to watch voids closely, and to make every effort to hold them at a minimum. The extra weight is advantageous, but security against compression and rearrangement with resulting temporary quicksand conditions, can be best reached in this way.

A strict application of these principles may reduce the number of hydraulic-fill dams that are built by eliminating that method of construction from consideration where the available material contains too many very small particles. It may also increase considerably the volume and cost of those that are built. It would seem, however, that following them to a logical conclusion, with such testing as can reasonably be done, will result in eliminating present uncertainties and in putting a most useful method of dam construction on a definite and safe basis.

NEW DRY DOCK, NORWAY.—With the assistance of the Norwegian State, which has the prior right to its use, the new dry dock referred to on page 262 *ante*, which has been in course of construction for some five years, is now in use. It was built by the Aker Engineering Company, Christiania, and is able to accommodate the largest vessels of the Norwegian merchant navy, some of which have hitherto had to go to Newcastle or Copenhagen for docking.

THE EFFECT OF HEAT SUPPLIED TO THE BLAST FURNACE.

*Variations in the Heat Supplied to the Blast Furnace, and their Effect on the Fuel Consumption.**

By W. W. HOLLINGS.

IT has not infrequently been observed that, when some notable addition has been made in the supply of heat to the blast furnace, the resulting economy in fuel has exceeded the theoretical fuel equivalent of the heat actually added. Two prominent examples of this discrepancy were afforded by the introduction of the hot-blast by Neilson and of the dry-blast by Gayley.

In his "Chemical Phenomena of Iron Smelting," in the section "On the Theory of the Hot-blast," the late Sir I. Lowthian Bell quotes a specific instance where an increase in the temperature of the air from 60 deg. F. to 450 deg. F. reduced the coke consumption from 60 cwt. to 38 cwt. per ton of pig iron, a saving of 22 cwt., or 36·66 per cent. Now, per ton unit of carbon burnt in the furnace, the above increase in the blast temperature would mean the addition of, roughly, 300 cals. to the hearth, an amount of heat equivalent to 2·43 cwt. of carbon burnt to CO before the tuyeres, or a saving of only 12·15 per cent. Similarly, from the account given by Mr. Gayley of his original application of the dry-blast, it would appear that by drying the air—and incidentally increasing its temperature from 362 deg. C. to 465 deg. C.—he reduced his coke consumption from 2,147 lb. per ton of pig-iron to 1,726 lb., a saving of 421 lb. or 19·61 per cent., whereas on the basis of any theory hitherto advanced the maximum saving possible was between 12·00 per cent. and 13·00 per cent.

When Mr. Gayley first published his results in the autumn of 1904, in common with many others the Brymbo Steel Company was much attracted by the seeming possibility of a considerable reduction in fuel consumption. Determinations taken over an extended period had shown that the moisture in the atmosphere at Brymbo ran on an average just over 3 grains per cubic foot, and no difficulty was anticipated in being able to reduce this to the region of 1 grain. If Mr. Gayley was able to obtain a saving of practically 20 per cent. in his fuel consumption by reducing the moisture in his blast from 5·66 grains to 1·75 grain per cubic foot, or by 3·9 grains per cubic foot, it was assumed that an economy of not less than 10 per cent. should be attainable by a reduction of 2 grains per cubic foot.

The matter was temporarily left in abeyance, but as time went on and confirmatory reports were received from various sources, it was decided, in 1909, to proceed with the erection of a plant for drying the air. The method adopted finally was that of freezing out the moisture by means of the ammonia absorption process. The necessary machinery was supplied by Messrs. Ransome & Rapier of Ipswich, and as far as this part of the process was concerned, there was no cause for complaint. From the moment of starting up, the plant was all that could be desired for economical and efficient working; in fact, the cost of operating came out lower than had been figured on. Unfortunately, the practical results obtained from its application fell very far short of the economy hoped for, the actual saving being only 3·34 per cent., in place of the 10 per cent. anticipated.

In view of the brilliant results obtained by Mr. Gayley, this wide difference appeared to call for some explanation, and the search for such an explanation resulted in the construction of the theory which is advanced in this paper. This theory accounts satisfactorily for the great saving attained on the introduction of the hot-blast by Neilson and also for that obtained by Mr. Gayley with his dry-blast, whilst at the same time reconciling the wide difference in the results obtained by Mr. Gayley and the Brymbo Steel Company.

If the blast-furnace be regarded solely as a medium for the production and absorption of heat, the heat produced will be made up of—

(*a*) The heat brought in by the blast;
(*b*) That developed by the combustion of the fuel;
(*c*) That evolved in the formation of the slag and iron compounds;

whilst the heat absorbed, including losses by radiation and cooling water, will be the heat developed less that carried away in the furnace gases.

It is common knowledge that in a furnace working on a given burden, a certain amount of heat will be necessary for the production of a ton of pig-iron of a given grade, and that of this total heat a certain proportion will be absorbed in the furnace (including that necessary to satisfy the losses by radiation, cooling water, &c.) and a certain proportion will escape in the exit gases. If further heat be added to the furnace, the amount of fuel necessary to produce the total heat required for the production of a ton of metal of the same grade must be reduced.

Now, in the reduction of the iron ore used in making a ton of pig-iron from a given burden, the amount of oxygen liberated from the ore is approximately constant, varying only very slightly with the proportion of impurities reduced with the iron, so that, even though the quantity of fuel per ton of pig-iron may vary, the amount of carbon oxidised to CO_2 by the reduction of the ore remains approximately the same per unit of product. If the blast temperature be raised, not only is less fuel required to develop the same amount of heat as before, but in diminishing the quantity of fuel the ratio CO_2 to CO in the gases is increased, resulting in a further addition of heat through the improved calorific efficiency of the carbon burnt. Similarly, this diminution influences the proportion of heat obtained from the formation of the slag and iron compounds per unit carbon burnt, increasing the supply from this source also.

Furthermore, by carrying the amount of heat brought in by the blast, the number of calories conveyed to the burden per unit weight of the ascending gases is also changed, the absorption by the burden appearing to approximate to the formula—

$$a_2 = a \sqrt{\frac{c_2 w}{c w_2}}$$

where a, c and w represent respectively, the amount of heat absorbed, the number of calories developed, and the weight of gases evolved per unit carbon burnt before the change, and a_2, c_2, and w_2 the same after the change. This change in the absorption of heat by the furnace takes place at the expense of the furnace gases, which are correspondingly, but inversely, varied in temperature.

For example, let it be assumed that a unit of pig-iron of a certain grade and from a given burden requires a unit of carbon for its production, and that the thermal ratio $CO : CO_2 = 0·25 : 0·75$ in the gases (by thermal ratio is meant the proportion CO_2 to CO actually participating in the production of heat). The unit of carbon here produces 3,810 cals. If 500 cals. be brought in by the air and 100 cals. evolved in the formation of the slag and iron compounds, the total heat developed per unit carbon burnt in the furnace will be 4,410 cals., and if 550 cals. be carried away in the furnace gases the amount of heat "absorbed" by the furnace is 3,860 cals.

Should the temperature of the blast be raised sufficiently to increase the supply of heat from this source to 700 cals.—an addition of 200 cals.—the amount of carbon required to produce the necessary heat for the production of the unit of pig-iron, assuming the ratio $CO_2 : CO$ to remain constant, becomes—

$$1.00 \times \frac{4410}{4610} = 0.9566;$$

but since the amount of oxygen liberated in the reduction of the pig-iron is the same as before, the thermal proportion $CO_2 : CO$ becomes $0·25 : 0·7066$ and the unit of carbon produces 3,864 cals., an increase of 54 cals. Similarly, the heat from the slag and iron compounds will be $\frac{100·00}{0·9566}$ or 104 cals., a gain of 4 cals., making the total from these two sources 58 cals. per unit carbon burnt in furnace.

Assuming for the moment that the weight of gases per unit carbon burnt in the furnace remains constant, the heat absorbed will be—

$$3860 \sqrt{\frac{4610}{4410}} = 3946 \text{ cals.},$$

an increase of 86 cals., involving a diminution in the temperature of the gases at their exit.

Thus the increment of heat in the furnace per unit carbon burnt from the improved chemical and physical efficiency directly resulting from the addition of 200 cals., amounts to 144 cals. If these 200 cals. induce an internal augmentation of 144 cals., these 144 cals. will in their turn be responsible for a further addition of $\frac{144}{200}$ of 144 and so on. Therefore:

"Any variation in the amount of heat supplied to the blast furnace involves a secondary and complementary series of changes in the amount of heat produced and absorbed internally; and the proportion borne to the initial variation by its complementary internal change constitutes the ratio of an infinite geometric series of which the primary variation itself forms the first term."

If a be taken to represent the initial variation and r the proportion borne to it by its complementary internal change, the total variation involved will amount to the sum of the series $a + ar + ar^2 +$, &c., to infinity; or $\frac{a}{1 - r}$.

In the example under consideration, the values for a and r respectively will be 200 and 0·72; $\frac{a}{1 - r}$ will then amount to 714·3 cals., and this will be the ultimate calorific effect on the furnace for that burden by the addition of 200 cals. per unit of carbon burnt, and the amount of carbon required per unit of pig iron will be—

$$1.00 - \frac{4410}{5114.3} = 0.8623$$

It will be as well to note here that in dealing with dry blast there is a change in the proportion of N_2 per unit of air blown when compared with normal blast, and consequently a change in the weight of gas formed per unit carbon burnt as tuyeres. The proportional relationship $a : ar$ and $ar : ar^2$ will be thus effected, and it becomes necessary to sum the series in two steps. The value for the internal change complementary to the initial variation should be first ascertained, and the series summed from this point on. In the above example 0·9566 becomes the fuel base for the series, and 144 the initial variation.

If the above theory—which was first evolved some six years ago, but has been held up until now principally for reasons connected with the war—be applied in detail to the figures of Mr. Gayley's original trial it will be found that, for a reduction of the moisture in the air blown from 5·66 grains to 1·75 grain per cubic foot, and an increase in the blast temperature from 362 deg. to 465 deg. C., the theoretical consumption corresponding to the initial figure of 2,147 lb. of coke per ton of pig iron works out at 1,675 lb., showing a saving of 21·92 per cent. During the trial in question, Mr. Gayley's actual consumption varied between 1,462 lb. and 1,952 lb., with a mean of 1,726 lb. for the whole period of the trial—an economy of 19·61 per cent. The average

* Paper read before the Iron and Steel Institute at Cardiff, September 22, 1920.

temperature of the exit gases under dry-blast was given as 191 deg. C. against 282 deg. C. when working with normal blast.

For the purpose of making a theoretical estimate of the temperature of the outgoing gases corresponding with the consumption of 1,675 lb., the losses through tuyere and cooling water had to be included under one head with the radiation losses, as no separate figures were obtainable for these items. This obviously introduces a source of error, as there is no proportional relationship connecting these three sources of loss. It was assumed that the combined loss for these three items followed the formula for heat absorption previously given. The temperature obtained for the exit gases to correspond with the consumption of 1,675 lb. of coke was, on this assumption, 154 deg. C. and that for 1,726 lb. was 169 deg. C. in place of the 191 deg. C. observed in practice.

Of the 21·92 per cent. saving in fuel obtained theoretically, 11·34 per cent. was shown to be due to the actual drying of the blast and 10·55 per cent. to its increase in temperature from 382 deg. to 465 deg. C. In the case of Brymbo, the theoretical saving obtained for a reduction in the moisture in the blast from 3·1 grain to 1·3 grain per cubic foot amounted to only 2·18 per cent. as against 3·34 per cent. obtained in practice. In this case the drying of the air was slightly offset by a diminution in the blast temperature from 632 deg. to 621 deg. C.

Owing to the lack of information respecting the amount of heat carried away in the tuyere water, the heat delivered to the furnace by the blast had to be taken at the temperature of the "bustle," whereas it ought to have been somewhat less than this. As the temperatures of the dry and normal air differed somewhat in both cases this introduced a small error. In the case of Mr. Gayley, the dry-blast being at a considerably higher temperature than the normal blast, there would be a slightly greater loss through tuyere water, diminishing somewhat the theoretically calculated saving. With Brymbo, on the other hand, the temperature of the dry air was slightly the lower. In both cases, had it been possible to include tuyere water losses, the result would have been to bring the theoretical results even more nearly into line with the practical.

Before the theory which has been advanced in this paper could be applied practically to any specific case, it was necessary to assume the existence of some stable relationship between the burden working at its maximum efficiency and the gases given off during its reduction. It was also essential to have an absolutely representative analysis of these gases, in order to establish accurately the initial calorific value of the unit of carbon burnt. In this respect it was noted that the CO_2 and CO contents of the furnace gases, whilst working on normal blast were given by Mr. Gayley as 13·00 per cent. and 22·3 per cent. by volume respectively. These figures cannot be representative, for if as high a figure as 4·00 per cent. be assumed for the H_2 in order to reduce as far as possible the proportion of N_2, and the gases be then placed on a basis of atmospheric N_2 per unit carbon burnt at tuyeres, it will be found that the amount of carbon other than that due to combustion at the tuyeres will not be sufficient to satisfy the proportion known to have been introduced by the limestone alone. For this reason it was necessary to reject the above values for CO_2 and CO and to build up a gas from the burden in accordance with some given relationship. As whatever goes into the furnace must come out, either in the slag and pig iron or in the gases, such a relationship should be possible of demonstration if a sufficiently comprehensive and accurate research be carried out.

An investigation on a straight hematite ore burden, owing to its simplicity, appeared to offer the most promising field. The author was fortunate enough to have before him the results of a very remarkable trial on such a burden carried through on the Isabella furnaces in 1909, by their superintendent, Mr. Maccoun, with a view to establishing a heat balance for the furnace.

The results were embodied in a treatise entitled "Blast Furnace Advancement," and read before the American Iron and Steel Institute in May, 1915. It will be noted that the research was on the same furnaces as those on which Mr. Gayley carried out his dry-blast trials.

The root idea assumed by the author of the present paper, and applied subsequently in making the Gayley and Brymbo calculations, was that the carbon burnt above tuyeres was not a capricious quantity, but was made up of the small proportion required for the "direct" reduction of the silicon and phosphorus and a balance consisting of the amount necessary to satisfy the equilibrium $\frac{CO_2}{CO}$ corresponding to the mean temperature of the zone of dissociation of the limestone. On this assumption the quantity of carbon burnt above tuyeres for a given burden remains approximately constant, and its proportion to the total carbon burnt increases as the fuel consumption per ton of pig iron diminishes. When investigating Mr. Maccoun's figures it was found that if all the iron and manganese were held to exist in the ore in the form of the highest oxides, there was an excess shown in the amount of O_2, from sources other than the blast, over that actually present in the gases. The whole of the manganese and a small percentage of the iron was therefore held to exist in the ore in the form of the lower oxide in complex ferro- and manganoaluminium-silicate minerals, though possibly a small amount of this ferrous iron may be due to the reaction $FeS + CaO + C = Fe + CaS + CO$.

When dealing subsequently with Mr. Gayley's figures it was interesting in this case, likewise, to note that, unless the whole of the manganese and about 2·5 per cent. of the iron were held to exist as lower oxides, it would be impossible to devise a pig iron having a sufficiently low "oxygen equivalent" to correspond both with the fuel consumption and the composition of the burden. These complex silicates of manganese and iron were assumed to be reducible only on their composition being broken up on "slagging" and the equivalent iron and manganese were added to the phosphorus and silicon as substances obtained by direct reduction, *i.e.*, by means of carbon direct or by CO at a temperature superior to 1000 deg. C.

If the N_2 contained in the coke, and the exact amount of moisture contained in the blast be known, the constituents of the furnace gases can be placed on a basis of atmospheric N_2 per unit carbon burnt at tuyeres, and so classified proportionally as products of combustion at tuyeres, and products derived from the reduction processes in the furnace. This method was employed in dealing with Maccoun's figures. It was then noticed that the proportional relationship between the oxygen extracted from the ore and the carbon burnt at tuyeres could be accurately established. If the analysis of the pig iron be known, its "oxygen equivalent," or the amount of oxygen extracted from the ore in the production of a unit of pig iron, is also known. If this latter figure be divided by the amount of oxygen extracted from the ore per unit of carbon burnt in the furnace, the amount of carbon necessary to produce a unit of pig iron will be the result. In Mr. Maccoun's trials the actual amount of coke consumed per ton of pig iron made was 1901·6 lb. The amount obtained by estimation from the gases by the above-mentioned method was 1901·4 lb.

The author is conscious that no law can be laid down as the result of a single trial however completely and accurately carried out. The figures derived from Mr. Maccoun's research, however, are in such close agreement with the hypothetical relationship between burden gases, and fuel as imagined by him, that he ventured to assume this relationship as fact when it subsequently became necessary to build up a gas on dealing with the Gayley and Brymbo trials. Much work would be necessary before it could be established whether or not this relationship holds true for all burdens. Mr. Maccoun's figures showed that the amount of carbon consumed by "direct" action only amounted to 40 lb. on a total of 1,648 lb. carbon burnt in furnace, or slightly less than 2·5 per cent., representing about 1 per cent. by volume in his furnace gases, so that very accurate sampling and analysis would be required to detect any slight variations in the total amount of "direct" carbon. A continuous 24-hour sample treated on the principle of organic analysis, and in which the residual N_2 would be estimated by measurement, would seem to promise the best results. In dealing with the figures from Mr. Maccoun's research the writer ventured to differ from the treatment given on a couple of small points. He substituted "international atomic weights" throughout, in place of the ordinary round figure values, and made due allowance for the effect on the composition of the gases and the "oxygen equivalent" of the pig iron by the addition to the burden of 5·8 per cent. scrap on the make of pig iron. The fundamental data obtained by Mr. Maccoun and given in the Year Book for 1915 of the American Iron and Steel Institute remained untouched.

The suggestion that the carbon burnt above tuyeres is a fixed quantity for a given burden may be challenged, on the ground that the use of soft coke increases the proportion of CO in the gases, and that this increase in CO is due to the reaction $CO_2 + C = 2CO$; which reaction would result in a consumption of carbon above tuyeres.

The author has not seen any comparative analyses based on the proportion of atmospheric N_2 to a unit carbon burnt at tuyeres which would prove this point, and in default of such analyses he suggests that the increase in CO is due primarily to physical causes. His reasons for so doing are twofold :—

(*a*) Owing to the great efflux of CO_2 from the decomposition of the limestone and the comparatively high temperature prevailing in this zone of the furnace, it is reasonable to suppose that the equilibrium $\frac{CO_2}{CO}$ corresponding with the conditions and temperature prevailing at this point will be satisfied, and that the reaction $CO_2 + C = 2CO$ will take place. Once this zone is passed, however, the proportion of CO_2 necessary to form an equilibrium increases with such rapidity as the temperature falls that, taking into consideration the velocity of the ascending gases, it appears probable that at no time after they have passed through this zone will the formation of CO_2 be sufficiently rapid to overtake the equilibrium demands. The tendency, in fact, would be towards the reaction $2CO = CO_2 + C$ rather than towards the converse.

(*b*) Assuming that the reaction $CO_2 + C = 2CO$ actually does take place, once the gases have passed up through this zone of decomposition of the limestone there is always an abundant quantity of deposited carbon present in an exceedingly favourable condition for chemical reaction, and it appears probable that the CO_2 would take this carbon in preference to attacking the soft coke. As carbon deposited by the reaction $2CO = CO_2 + C$ is entirely carbon previously burnt and simply transferred, it would not show as an addition to solution loss.

The cause for this increase in CO, and consequent increase in the consumption of fuel when using soft coke, may be that, as the coke descends in the furnace, abrasion and crushing take place, causing "fines" and that these "fines" tend to fill up the interstices in the burden; the velocity of the gases is thereby increased, giving them less time to react with the ore, whereby less CO_2 is formed, the proportion of CO is increased, and the calorific efficiency of the carbon unit is decreased.

This view is supported by the fact that a considerable saving in fuel has been observed when the charge has been crushed to a uniform size. Apart from any economy which may occur from the practical consideration that uniform size of ore makes for uniform reduction and consequently uniform working, when the materials of the charge are all reduced to the same size, the maximum amount of free space between the individual particles is obtained. The velocity of the gases is thereby decreased, giving them more time to act on the ore, whereby more CO_2 is formed, the calorific efficiency of the carbon unit increased, and the amount of fuel necessary per ton of pig-iron diminished in consequence. In both the above cases the amount of loss or gain in the heat, brought about by the change in the proportion of CO_2 would effect the intervention of the geometric ratio described previously, and the primary effect would be intensified in proportion.

If a furnace be blown with oxygen-enriched air, a diminution in the weight of gases per unit carbon burnt at tuyeres results from the reduction in the proportion of N_2 present in the blast. There will be consequently an increase in the amount of heat absorbed by the burden due to the decrease in the value for w_2 in the formula—

$$a_2 = a\sqrt{\frac{c_2\, w}{c\, w_2}}.$$

The increment of heat to the furnace from this source will also be subject to the geometric ratio. Even taking this effect into consideration, it will be clear from the above that not much economy is to be awaited from a small increase in the percentage of oxygen in the blast, especially when it is recognised that there is at the same time a reduction in the amount of heat conveyed to the furnace per unit carbon burnt, due to the diminished proportion of N_2 in the mixture blown.

The conclusions to be arrived at from the premises in this paper are :

(1) That a relationship exists in the blast-furnace between heat added *to* and heat developed and absorbed *within* the furnace, whereby the ultimate calorific effect of a variation in the heat supplied is in geometric ratio to the amount of the initial change; and consequently,

(2) That for countries with such a low average absolute moisture as England, it does not pay to install the dry-blast.

(3) That the crushing of the materials of the charge to a uniform size may be expected to result in a considerable economy of the fuel required per ton of pig-iron.

(4) That the process of blowing with oxygen-enriched air is not likely to result in any appreciable saving for a small percentage increase in the oxygen.

In conclusion, the author wishes to express his indebtedness to Mr. Maccoun, whose admirable work was of the utmost assistance to him in the development of the views brought forward in this paper. To his brother, Mr. J. Spencer Hollings, likewise he offers grateful thanks for much kindly help in revising the text.

United States National Advisory Committee for Aeronautics. — The reports recently issued by this body include one dealing with the kiln drying of timber for aeroplane construction, another devoted to the design of wind tunnels and wind tunnel propellers, and a third describing the properties of various special types of radiator for aircraft. In the last mentioned report three classes of radiator are dealt with, viz., radiators with flat-plate water tubes, fin and tube type radiators and radiators that whistle in an air current. Curves and tables showing the performance of each type are included, and comparisons are drawn between the flat plate and whistling types. Empirical equations are also given for estimating the performance of flat-plate radiators of various dimensions and the effect of yawing the radiators is also briefly considered. Other reports dealing with the stability of parachutes and helicopters, bomb trajectories, and limiting velocities of bodies falling from a great height have also reached us as well as one comparing the United States and British standard pitot-static tubes. These tubes were compared at wind-speeds ranging from 20 to 160 m.p.h., and, as we should have expected, were found to be in complete agreement within the limits of experimental errors, both giving true pitot readings. Any of the above-mentioned reports may be obtained on application from the National Advisory Committee for Aeronautics, Washington, D.C., U.S.A.

Slow Decomposition of Silicates by Carbonic Acid.—Assuming that carbonic acid should, at ordinary temperatures, be able to react with silicates and even with hydrated silica itself, C. Matignon sealed up in 1909 some natural silicates and also glass, all well powdered, with water in glass vessels which were charged with CO_2 at a pressure of 10 atmospheres. The vessels were opened again recently after an interval of ten and a quarter years. On May 17 last Matignon and Miss Marchal communicated the results of their examination to the Paris Académie des Sciences. It was found that all the substances had been attacked, though only slightly. As the vessels were left to themselves and apparently not disturbed in any way, the conditions, perhaps, hardly favoured chemical action. The corrosions were in the following order: Wollastonite, calcium silicate, $Si\,O_3\,Ca$, was irregularly pitted; talcum, mica and diophase, $Si\,O_3\,Ca$, and quartz itself showed smaller pits; asbestos had lost its lustre, but was hardly corroded, and the attack on glass was almost imperceptible. The experiments are not conclusive and are to be continued. Only 2 grams of the substance were taken in each case, and the experiments were made in glass vessels which would themselves be attacked. There is no information about the kind of glass used. One is rather surprised to learn that quartz suffered more than glass; on the other hand, the delicate weathering tests on optical glasses do not always accord with general chemical stability tests.